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NUCLEAR CHEMISTRY, THE NEUTRON AND ARTIFICIAL RADIOACTIVITY[1]

By Professor WILLIAM D. HARKINS

UNIVERSITY OF CHICAGO

(1) INTRODUCTION

NUCLEAR chemistry is just a decade old, yet it is now the most active of all the special branches of science. Nuclear reactions are very similar to ordinary chemical reactions, except that they deal with matter which is a million million times more dense than ordinary matter, and on this account the forces are extremely high and the energies involved are a million times greater than those of ordinary atomic chemistry.

[1] Address presented before Section C of the American Association for the Advancement of Science, and the St. Louis Section of the American Chemical Society, St. Louis, January 1, 1936. The section on deuterium (heavy hydrogen) has been omitted, and in its place an abstract of a paper "Deuterium as a Reagent in Nuclear Chemistry" presented at the April meeting of the American Chemical Society, has been substituted.

The purpose of this address is to outline some of the nuclear work done at the University of Chicago and especially to emphasize the point of view developed during the last few years, which is that only reactions of the chemical type occur among nuclei. Thus atoms may be artificially synthesized, but not artificially disintegrated.

Thus when two atomic nuclei meet they first combine to form a new nucleus, which on account of its large content of energy is unstable and therefore has a life which is short in large scale time, but not excessively short on a nuclear time scale. This intermediate product nucleus may then disintegrate in any one of a number of ways, which depend upon the nature and state of the metastable nucleus. Thus the disintegra-

tion is a step separate from the synthesis which precedes it.

(2) Mass, Energy and Fundamental Particles

The most obvious property of matter is mass. According to present theory all substances are built up from four fundamental particles: the proton, the neutron, and the negative and positive electron. There is, in addition, another particle, the little neutron, or neutrino, which is supposed by current theory to play a part in nuclear chemistry, but no definite evidence of its existence has been obtained.

TABLE I

Elementary Particles

One unit of Mass = 1.65×10^{-24} gram

Particle	Charge	Mass	Spin
Proton	Unit +	1.0075	½
Neutron	Zero	1.00856	½
Negative electron	Unit −	0.00055	½
Positive electron	Unit +	0.00055	½
Neutrino	Zero	Very small	½
Photon	Zero	Varies as frequency	0
(b) Light nuclei used as projectiles			
Deuterium or Heavy Hydrogen	Unit +	2.0142	1
Helium	+ +	4.0034	0

According to Einstein mass (M) and energy (E) may be considered as identical, so the equation

$$E = M$$

may be used. Since, however, it is customary to express energy and mass in different units, a conversion constant, found to be the square of the velocity of light (c^2), must be used with such units, or

$$E = c^2M = 9 \times 10^{20}$$

Thus a weight of one gram contains an energy of 9×10^{-20} ergs.

This equation was used by Swinne (1914) to calculate the mass lost in radioactive disintegrations, and by Harkins and Wilson (1915) to calculate the energy liberated by a nuclear reaction of hydrogen. The energy liberated by one pound of hydrogen, when it unites with a heavier atom was found by them to be of the order of a million times greater than that of a chemical reaction of atoms, since it was found to give as much heat as the burning of ten thousand tons of coal.

The photon is a particle assumed in the modern corpuscular theory of light. Its mass is a constant $\left(\frac{h}{c^2}\right)$ times the frequency (ν) of the light. When the energy of the photon is very high, as it commonly is when emitted by a radioactive substance, it is designated as a γ-ray. The mass of a γ-ray of high energy has recently been found to be as high as 0.010, and in experiments on lithium it has been claimed that a mass of 0.017 has been observed. Thus the remarkable result has been obtained that "particles" of light have been discovered which have a mass twenty (possibly even thirty) times greater than that of an electron at rest. This gives the peculiar relation that the mass associated with a unit of light may be greater than that of a material particle.

(3) Fast Atoms

Atoms of helium are shot out from radioactive substances with velocities as high as 12,800 miles per second. These fast atoms pull at least one negative electron from each atom through which they pass. The result is that the track of every fast atom is defined in a gas by a sharp line of many thousands of positive and negative ions. Now in 1911 C. T. R. Wilson found that if the gas is supersaturated with water vapor, each ion becomes the center of a minute water droplet. If a brilliant light shines through the gas the track of the atom becomes visible as a fine bright, continuous line of white fog or cloud, and almost always such a line is straight.

The tracks of electrons, except those from cosmic rays, are, on account of the small mass of the electron, very crooked, and dotted, that is non-continuous. The track of a hydrogen atom (charge +) is straight, but commonly only about one fourth as broad as that produced by a helium atom (charge ++).

By means of photographs of these Wilson cloud or fog tracks the characteristics of fast atoms may be determined and in Table II these are compared with those of slow atoms.

TABLE II

Behavior of Slow and Fast Atoms of Helium in Air

Slow atoms, velocity 7/10 mile per second	Fast atoms, velocity 10,000 miles per second
1. Average velocity constant over large intervals of time.	1. Velocity decreases with extreme rapidity.
2. Deflected several times in each smallest microscopic region.	2. Move several inches in a straight line until velocity is lost.
3. Collides with another atom on average each $\frac{1}{300{,}000}$ inch.	3. Would need to travel about a mile to give a sharp collision.
4. Apparent diameter 2×10^{-8} cm.	4. Apparent diameter 7×10^{-13} cm.

Thus atoms at very high relative velocities behave in their relations toward collision as though they are extremely small in comparison with slow atoms. Thus a fast atom acts as if it has a diameter ten thousand times, an area a hundred million times and a volume a million million times smaller than a slow atom.

(4) THE NUCLEUS

These anomalous relations are explained very simply by the theory of Rutherford. This considers that in slow collisions the outer parts of the two atoms come in contact. At high relative speeds the atoms pass through each other (not, however, without a partial loss of individuality), but collisions occur only when their dense central portions, called nuclei, happen to meet. The nucleus of the atom as so defined has a diameter about one ten thousandth that of the atom as a whole. A cubic centimeter of lightly packed nuclei would thus weigh about ten million tons, or a thimble could contain the material of a hundred battleships. This illustrates the great density of material in nuclei.

The outer part of the atom according to this current style of theory is an aura or cloud of relatively tenuous nature which consists entirely of negative electrons.

The number attributed to this cloud, commonly called the number of electrons in the neutral atom, determines the chemical and physical behavior of the material made up of these neutral atoms or what is considered as an element. The same number gives the position of the element in the ordinary periodic system of the elements.

Thus in the most abundant of all atoms, that of the most common kind of oxygen, there are eight negative electrons in the non-nuclear aura, and, if the atoms are to be neutral, there must be a charge (Z) equal to that of 8 electrons, but positive, on the nucleus.

(5) THEORY OF THE COMPOSITION OF ATOMIC NUCLEI

In 1923 the writer suggested that all atomic nuclei have a composition represented by the formula

$$(np)_z\, n_I$$

Where n is a neutron with a zero charge, p is a proton with a single positive charge, so Z is the number of positive charges in the nucleus as a whole. The values of Z (atomic number) range from 0 to 92 (−1 is included for the negative electron), and I (isotopic number) varies from −1 to 54.

For ordinary oxygen the value of Z is 8 and that of I is zero, so the oxygen nucleus consists of 8 neutrons and 8 protons.

The mass of this oxygen atom is 16 by *definition*. Each non-nuclear electron has a mass of 0.00055, so the mass of the nucleus is 15.99945, and the average mass of a neutron or proton is 0.999725. In the free state a proton has a mass of 1.0075, and a neutron of 1.0085, as nearly as is known.

Thus if 8 neutrons and 8 protons could be packed together into an oxygen nucleus they would lose 0.82 per cent. of their mass. This is called the packing effect.

It is simpler, and gives the same numerical result, if it is considered that eight neutrons and eight hydrogen atoms give a complete atom of oxygen. Thus 8 neutrons each when free of mass 1.0085 and 8 hydrogen atoms of mass 1.00807 are present in an oxygen atom of mass 16.0000, or the packing effect is 0.8217 per cent. That is 1/122 of the mass of the initial particles has been lost as energy. It must not be supposed that such a complicated reaction as this can be made to take place in a single step.

Nearly all atoms, except the lightest, have masses which are expressed with moderate accuracy as whole numbers. The light atoms—neutrons, atoms of hydrogen, heavy hydrogen, lithium, beryllium and boron—have masses in which the decimal fraction may rise as high as 0.014. Thus if two light atoms were to form an atom heavier than oxygen, in general the mass expressed by the decimal would disappear as ordinary mass of the atom which is formed. If, however, a light atom is formed its decimal mass must be given to it. Atoms of high decimal mass undergo reactions more readily in general than those of low decimal mass. Thus beryllium of mass 9.*0136* undergoes nuclear reactions in general much more readily than oxygen of mass 16.*0000,* since it contains more available energy.

(6) HYDROGEN FROM NITROGEN

The first artificial transmutation of atoms was obtained by Rutherford, who in 1919 formed hydrogen from nitrogen. The apparatus which he used was extremely simple, since it consisted of a spinthariscope, invented by Sir William Crookes (1903). A radioactive salt or deposit on a piece of metal sends alpha particles against a screen of zinc sulphide, which gives bright scintillations, but not at distances greater than the range of the α-particles, which in general is not over 8.6 cm in air. In nitrogen, however, the scintillations were visible at distances as high as 28 cm, which indicated that a lighter particle, assumed and later proved to be hydrogen, was emitted. Rutherford therefore assumed that the nitrogen nucleus is disintegrated to give hydrogen and carbon by the blow delivered by the helium atom, which immediately escapes.

$$_7N^{14} \rightarrow {}_6C^{13} + {}_1H^1$$

This is just as though in a collision of two billiard balls one of them should break into two pieces.

(7) NUCLEAR CHEMISTRY

This is called "nuclear disintegration without capture." To reveal the details of such an event it was essential to adopt a more refined experimental method. That suggested and used by Harkins and Ryan was

to take as a source of high speed helium atoms a deposit of thorium C′, which gave the fastest known atomic projectiles. These are helium atoms with an initial velocity of 0.0688 that of light, or 12,800 miles per second. Such an atom has an energy of 8.761 million volts. These atoms were allowed to shoot into nitrogen at about atmospheric pressure in a Wilson Cloud Chamber, and the tracks were photographed. The first twenty thousand photographs did not show a single disintegration, but further thousands of photographs, by the use of exactly this method, were taken by Blackett in Cambridge and Harkins and Shadduck in Chicago. These showed that the earlier interpretation of Rutherford's experiment was erroneous, since the photography demonstrated that the projectile was captured.

Thus the primary action was found to be the formation of a new atom. The reaction is exactly analogous in form to those most commonly found in chemistry in which A and B react to form C and D.

For example:

$$_{7}N^{14} + {}_{2}He^{4} \rightarrow {}_{9}F^{*18} \rightarrow {}_{8}O^{17} + {}_{1}H^{1}$$

Nitrogen + Helium → Fluorine → Oxygen 17 + Hydrogen.

This indicates that the primary action is the union of nitrogen and helium to form fluorine. The fluorine atom, however, contains the energy of not only the mass of the nitrogen and the helium atoms, but also the kinetic energy of the helium atom. This is more energy than represents a stable state of an atom of fluorine, so this "excited" nucleus disintegrates into an atom of oxygen and one of hydrogen which fly off in two different directions.

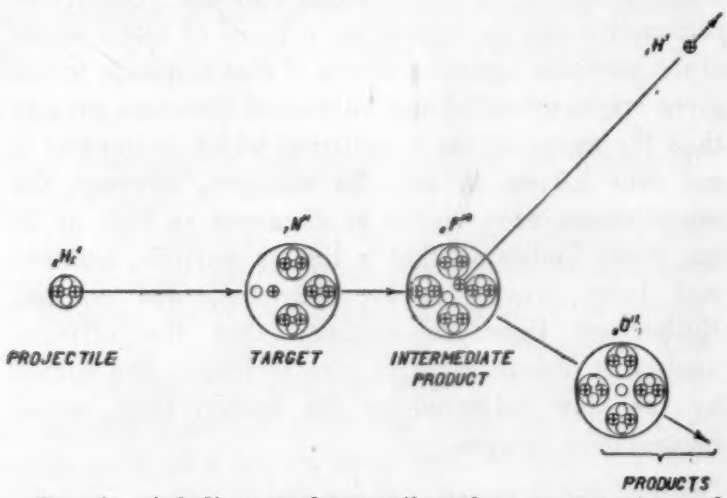


FIG. 1. A helium nucleus strikes the target nucleus of nitrogen and unites with it to form an intermediate fluorine nucleus. This moves at high speed and finally disintegrates after a short life into hydrogen and oxygen. In this case the oxygen nucleus is stable but often such a nucleus is unstable and a second disintegration ensues. If the projectile is a proton and the target carbon of mass 12 the intermediate product nitrogen 13 has a life of 10.5 minutes and the final products are carbon 13 (instead of oxygen 17) and a negative electron (instead of hydrogen $_{1}H^{1}$).

Thus this reaction was proved to be a disintegrative synthesis, or disintegration by capture, instead of a pure disintegration or disintegration without capture.

The discovery of this reaction gave birth to nuclear chemistry.

(8) Atoms Disintegrate Only by Use of Their Own Internal Energy

In natural radioactivity an atomic nucleus suddenly disintegrates into two parts, which fly apart at high velocities. Thus a radium nucleus disintegrates into a helium nucleus and a radon nucleus.

$$\text{Radium} \rightarrow \text{Helium} + \text{Radon}$$

The kinetic energy of the helium and radon atoms comes from the internal or mass energy of the radium nucleus.

As many as five helium nuclei may be emitted in succession in five steps, in each of which a nucleus splits into two parts. It is probable that when by "artificial disintegration" the nucleus seems to split into three or four particles, the disintegration more frequently occurs in steps in which two particles separate in each step, with a short life for each intermediate metastable atom.

Until 1933, while as indicated in the last section it had been known for some years that many disintegrations occur by capture, it was believed that many others occur by non-capture. In this year, however, Harkins and Gans developed the mechanics of disintegration without capture, that is the simple physical type of disintegration, and were able to show that such disintegrations do not occur, that is, in all artificial disintegrations the energy is transmitted to the nucleus, for example, that of fluorine, only when the projectile is captured, as follows:

$$_{9}\text{Fluorine}^{19} + {}_{0}\text{Neutron}^{1} \rightarrow {}_{9}\text{Fluorine}^{*20} \rightarrow {}_{7}\text{Nitrogen}^{16} + {}_{2}\text{Helium}^{4}$$

and not

$$_{9}\text{Fluorine}^{19} \rightarrow {}_{7}\text{Nitrogen}^{15} + {}_{2}\text{Helium}^{4}$$

Thus this disintegration is, like those of natural radioactivity, brought about by the high internal en-

TABLE III

Projectile	Product	
α–particle	Primary from AB* Proton or Neutron	Secondary from C* + electron – "
Proton	α–particle, deutron, + electron	+ electron
Neutron	α–particle, proton, – electron	– electron
Deuteron	α–particle, proton, neutron, H^{3}	+ electron – electron

ergy (mass) of the fluorine nucleus of approximate mass 20. This atom contains not only the masses of the initial fluorine atom and of the neutron, but in addition all the mass it obtains from the kinetic energy of the neutron.

A summary of all known nuclear reactions gives the relations between the projectile and the products of disintegration, as shown in Table III.

An attempt has been made to obtain some information in regard to the life period of the intermediate nucleus AB* when massive particles are emitted. It is well known that in the reaction

$$ {}_{6}^{0}C^{12} + {}_{1}^{-1}H^{1} \rightarrow {}_{7}^{-1}N^{*13} \rightarrow {}_{6}^{1}C^{13} + {}_{-1}^{-2}\varepsilon^{0} $$

where ${}_{1}^{-2}\varepsilon^{0}$ is the positive electron, the intermediate nitrogen nucleus has a half life of about 10.3 minutes. For cases in which an α-particle is emitted by a fast neutron the writer has been able to show that the total life does not exceed 10^{-7} seconds, but has not been able to determine the actual value of the life period, which probably lies between 10^{-7} and something of the order of 10^{-17} to 10^{-19} or 10^{-20} seconds. It may be assumed that the period depends upon the structure of A, B, AB*, the nature of the products of the disintegration of AB*, and that it decreases, in general, with the velocity of the projectile B.

The idea that the synthesis, and not the disintegration, is the primary action, changes the view-point in connection with the nuclear stability. For example, the oxygen 16 nucleus, when used as a target, gives in general the smallest variety of disintegrations of any of the light nuclei. Also, carbon 12 gives an even smaller number of disintegrative-synthesis than oxygen with fast neutrons from beryllium and thorium C′. Thus the oxygen nucleus, with 8 neutrons and 8 protons, seems to be specially complete or stable with reference to the addition of other particles, and carbon, with 6 neutrons and 6 protons, toward the addition of a neutron. If, however, such additions occur, there is usually for the addition product some type of disintegration which gives a favorable energy balance. The importance of the synthesis has been emphasized by the specific action between slow neutrons, and certain nuclei, such as those of boron, cadmium and silver (also gadolinium), since these nuclei have a peculiarly great affinity, presumably due to resonance, for neutrons at certain low velocities. This is said to be due to the wave characteristics of the system.

The simplest assumption which can be made concerning the capture of the projectile, and the subsequent disintegration, is that the part of the energy which does not remain as, or change into, kinetic energy is largely transformed, provided the nucleus is analogous to a molecular system, into vibrational energy of the parts of the intermediate nucleus AB*, although some of it may be stored in the potential form.

While it may not be essential at the present time to know what particles in the nucleus are vibrating, it is nevertheless interesting in connection with the development of a more refined theory. As a preliminary measure it may be assumed that the vibrating particles are only protons, and neutrons, *e.g.*, 8 of each in the oxygen nucleus. Even on this assumption the emission of an α-particle seems probable from the energy standpoint alone, since usually 4 or 5 million e-volts more energy is required for the emission of a proton or a neutron, on account of the mass relations. However, the problem arises as to how the energy necessary for emission is to be transmitted to the two particular protons and neutrons which are emitted.

There are several types of evidence which indicate the probability that groups with a mass of 4, which may consist of 2 protons and 2 neutrons, or more rarely of 4 neutrons (possibly 2 pairs of neutrons) exist to some extent in such nuclei. These may be designated as α-groups, with a mass of 4, and a charge of 2, with more rarely a charge of zero.

Thus (1) the abundance of atoms of an approximate mass 4 m and a charge 2 m, where m is a whole number, is very much greater, up to atomic number 30, than all other types of atoms; (2) the atomic masses indicate that such nuclei are the most stable, that is, they exhibit the smallest values of M/m, where M is the exact atomic mass; (3) the relations of disintegrative syntheses themselves give some support to this theory.

In some reactions, as in the first of these two:

$$ {}_{5}B^{11} + {}_{1}H^{1} \rightarrow {}_{6}C^{*12} \rightarrow 3\,{}_{2}He^{4} \qquad (1) $$

$$ \text{or} \rightarrow {}_{4}Be^{8} + {}_{2}He^{4} \qquad (2) $$

three, instead of two particles are given as distintegration products, because energy is liberated by such a reaction, while an absorption of energy would accompany any other two-particle disintegration. Probably reaction 2 is commonly the first step in (1). Usually, however, the input of energy increases with the number of particles emitted, so in general increase of kinetic energy of the projectile favors an increase in the number of particles. Cosmic ray projectiles, with energies up to 10^{11} volts, have enough energy to cause the nucleus to split into a large number of particles.

As an example let a deuteron be added to a nitrogen nucleus. This would give, neglecting the kinetic energy of the deuteron, an excess of 20.5 million e-volts in the intermediate oxygen nucleus 0^{*16}. This would be sufficient energy to dissociate this into helium and carbon, which requires 5.6 million e-volts, into 4

helium atoms, (which uses up 12.5 million), into a proton and nitrogen 15 (also 12.5 millions), but is very far from being able to supply the 124 million e-volts necessary for complete conversion into protons and neutrons. This last process would also in general involve supplying a much larger amount of kinetic energy.

(9) Negative and Positive Electrons

Negative and positive electrons have the same mass, about 1/1830 that of a hydrogen atom, but differ in having opposite charges, though these have the same magnitude. The most remarkable difference is that negative electrons make up the outer part of all atoms (except neutrons, which are bare nuclei), while positive electrons seem to have only a very temporary existence.

Positive electrons were discovered by Carl Anderson (1932) in cosmic rays in which they occur in not very different numbers from negative electrons.

Theories of the atom leave no place for the existence of positive electrons inside atoms, but such electrons are known to come out of atoms. Thus in the nuclear reaction

$$A + B \rightarrow AB^*$$

if AB^* has a low isotopic number (I), such as -1, it may have a moderately short life (as 10 minutes) and lose its instability by the loss of a positive electron. In this case the atomic number decreases by one (nitrogen changes to carbon) and the isotopic number increases by 2.

Commonly, however, AB^* will dissociate into two nuclei C^* and D. If C^* is excited, it may lose either a negative electron (if I is relatively high) or a positive electron if I is relatively low, as compared with the value of I in the band of high stability.

If a positive electron is found to be emitted from an atom, a proton in the nucleus changes into a neutron

$$p \rightarrow n + \varepsilon^+$$

while if a negative electron comes out from the nucleus a neutron changes to a proton inside the nucleus.

$$n \rightarrow p + \varepsilon^-$$

If a positive and negative electron meet they mutually annihilate each other's charge, and the energy goes off as a photon or γ-ray with a mass of .00110 or the mass of two electrons, that is the energy of the γ-ray is $.00110 \times .93 \times 10^9$ volts, or one million volts.

A γ-ray of a million volts energy may in a nuclear electrical field be transformed into a positive and a negative electron. The reactions are

$$\varepsilon^+ + \varepsilon^- \rightarrow \gamma$$
$$\gamma \rightarrow \varepsilon^+ + \varepsilon^-$$

Thus particles may change into light and light into particles.

No one has as yet been successful in causing either a positive or negative electron to unite with any atomic nucleus.

Although either negative or positive electrons are produced in nuclear reactions, neither of them is supposed to exist in any nucleus. While a proton may give birth to a positive electron, and a neutron to a negative electron, neither the proton nor the neutron is supposed to contain an electron.

According to classical theory, an electron has a diameter 2,000 times larger than a proton, and modern theory, while it does not directly accept this idea, does implicitly assume that an electron is too large to be present in either a proton or a neutron, and is thus not found in any nucleus.

(10) Success and Failure of Helium as a Nuclear Projectile

Protons, neutrons, deuterons heavy hydrogen nuclei), and helium nuclei (α-particles) are now used as nuclear projectiles for the disintegrative-synthesis of atoms. Of all these the α-particle has the highest positive charge, that of 2. Since the repulsion between nuclei varies as the product of the charges, and inversely as the square of the distance, the repulsion is equal to a constant times $\frac{2Z}{r^2}$ where Z is the atomic number of the other nucleus.

The highest energy of α-particles found from radioactive substances is 8.761 million e-volts, which has been found insufficient to cause the α-particle to penetrate nuclei of charge higher than 19, that of potassium, often enough to give a detectable number of disintegrations. A very few faster α-particles are actually emitted, but their number is too small to be effective in this sense.

The energy necessary to cause a nuclear projectile to strike another nucleus is greatly reduced if instead of an α-particle, a nucleus of an atom of light hydrogen (a proton) or of heavy hydrogen (a deuteron) is used, since each of these nuclei has a unit charge, and the repulsion force between the two nuclei at any given distance is reduced to one half. This also reduces to one half the energy necessary for the projectile to reach any definite distance (r) from the other nucleus.

Thus protons of the same energy as α-particles are able to penetrate nuclei of much higher atomic number. However, with the energy now available they are not able to disintegrate nuclei of very high charge.

(11) The Neutron

The question may be asked: if even ten million volts of energy is not sufficient to shoot any positively

charged particle into a heavy nucleus, then how can heavy nuclei be built up from the lighter ones? A very simple answer to this question was given by the writer (April, 1920) by the assumption of the existence of atoms of zero nuclear charge, or neutrons, with a unit mass equal approximately to that of a hydrogen atom, and of heavier neutrons, particularly the double neutron, which were supposed to be present in other nuclei.

It was predicted that neutrons would contain no non-nuclear electrons, and would have no chemical, and almost none of the ordinary physical properties, aside from mass. It was considered that they would pass readily through the outer part of atoms, and through the region close to the nucleus in which α-particles are repelled, and attach themselves to the nucleus. Thus they were supposed to not be affected by what is now considered as the potential wall toward positive particles.

In addition it was assumed that isotopic atoms are formed by the addition of the neutron. This prediction has received recent confirmation by Fermi.

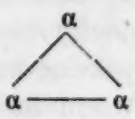
These predictions, including as they do the effects of neutrons in nuclear synthesis, cover all the important properties of neutrons, found within two years of the discovery of the existence of the neutron. Somewhat similar predictions were made two months later by Rutherford.

That the beryllium nucleus consists of two α-particles (helium nuclei) and one neutral nuclear particle, or neutron, was a part of the theory of nuclear composition developed by Harkins and Wilson (1915). Thus the beryllium nucleus should have, according to the simple theory, a mass of 8, but atomic weight determinations gave it the mass of 9. According to this theory the atomic weight of an element of even number should be a multiple of 4, since their nuclei were supposed to be represented by the formula $\alpha_{z/2}$, that is of a number of α-particles equal to half the atomic number.

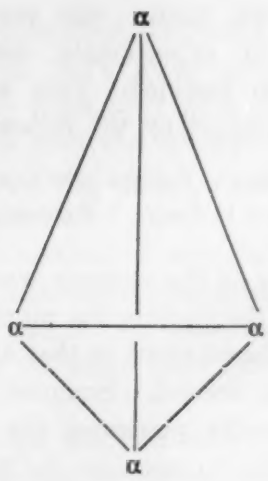
Thus the atomic weights should be:

α	α_2	α_3	α_4	α_5	α_6	α_7	α_8	
4	8	12	16	20	24	28	32	etc.
	Helium	Beryllium	Carbon	Oxygen	Neon			
		Magnesium	Silicon	Sulphur				

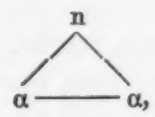
All these are correct except in the case of beryllium. This suggested the theory that a combination of two α-particles α-α is unstable, but



or



etc., stable. That is 3 particles or more are essential for stability. To change 8 to 9 and keep the charge constant a neutron must be added. Thus it was supposed that the system α_2 could be stabilized as in carbon by adding a third α-particle, but in beryllium the only possibility would be the addition of a neutron to form



or the ordinary formula for beryllium is $\alpha_2 n$. From this point of view a beryllium nucleus is a carbon nucleus in which one α-particle has been replaced by a neutron.

When beryllium is bombarded by α-particles from polonium radiations of the γ-ray type seem to appear, as was discovered by Bothe and Becker (1930). It was found by Curie and Joliot that the radiation formed in this way, if it is allowed to strike paraffin, or another material which contains hydrogen, ejects very fast protons, with ranges up to 26 cm in air, which corresponds to a velocity of nearly 3×10^9 cm per second, or one tenth the velocity of light. The energy is 5.7 million volts.

They suggested that the photons of the γ-rays strike the protons and by a process similar to the Compton effect, transfer energy to the protons. It was found that to do this the energy of the γ-rays must be 50 million volts, or an altogether surprising amount of energy since it is nearly 20 times larger than that of the most energetic rays from radioactive materials.

According to current opinion at the time, this was much more energy than could be released from the beryllium or any other atom when struck by an α-particle with an energy of five million volts.

If, however, it is assumed that the projectile which propels the proton forward is not a photon, but an atom, then the energy of this atom could be very much less. The natural assumption that the atom released from the beryllium nucleus is a neutron was

made by Chadwick (1932) who very quickly, by a remarkable set of experiments, demonstrated that his assumption is justified. This would mean that the neutron is released by the following reactions:

$$_4Be^9 + _2He^4 \rightarrow _6C^{12} + _0n^1$$
Beryllium + Helium Carbon + neutron

Since the mass of the neutron was supposed to be equal to that of the proton, the maximum velocity of the protons should be equal to that of the neutrons or 3.3×10^9 cm per second. Suppose now that these particles, supposedly neutrons, are shot into nitrogen. It is possible to calculate the maximum velocity which should be given by a head-on collision of neutron of mass 1 against a nitrogen nucleus of mass 14. This is found to be 4.4×10^8 cm per second, or an energy of 1.4 million volts, and a range of 3.3 mm in air. Photographs in nitrogen by Feather showed tracks of this length, in agreement with the assumption of the existence of a neutron.

It is possible to calculate the mass of the particle which would give these results. If m and v are the mass of the neutron, then since 1 and 14 are the masses of the proton and nitrogen nucleus respectively: the velocity of the proton

$$u_p = \frac{2m}{m+1} v$$

and of the nitrogen atom

$$u_N = \frac{2m}{m+14}$$

or

$$\frac{m+14}{m+1} = \frac{u_p}{u_n} = \frac{3.3 \times 10^{10}}{4.7 \times 10^9}$$

or

$$m = 1.15$$

That is, the result obtained from the early experimental work was that the mass of the neutron is 1.15 times that of the proton, while the most recent value of this ratio is 1.002.

(12) Properties of Neutrons

The most striking properties of neutrons are just those predicted in 1920, *i.e.*, first the ability at high velocities to penetrate very much greater distances through matter than any other atoms; second, notwithstanding this, to set other atoms in motion, and third, to unite readily with the nuclei of other atoms.

Neutrons dissipate their kinetic energy by collisions with atomic nuclei, while on the average charged nuclei such as fast protons, helium nuclei, etc., lose almost their entire energy by the work done in removing electrons from other atoms. This causes a great difference in their ranges. Thus with a velocity of 3×10^9 cm per second an α-particle travels about a foot in air, a hydrogen nucleus about the same distance, while a neutron goes about a quarter of a mile before it experiences a sharp collision with another atom, and may travel several miles before its velocity is reduced to that of ordinary molecules. The extremely great range of the neutron is due to its lack of any electrical charge. Its range indicates that while it collides with a nucleus much more often than with an electron, the nuclear collision is itself a rare event. Fast neutrons pass easily through a thick wall of metal, or of stone if the stone contains no water.

(13) Fast Neutrons

Neutrons have been found with velocities over 30,000 miles a second, but a more usual velocity if half of this. Fast neutrons form an isotope of the atom used as a target with a mass one unit greater, as

$$_7N^{14} + _0n^1 \rightarrow _7N^{*15}$$

With light nuclei such as this, the next step is to emit helium

$$_7N^{*15} \rightarrow _5B^{11} + _2He^4$$

Much more rarely a proton is emitted. Since the helium nucleus has a double charge, the proton a single charge, and the potential wall for such charged particles increases with the charge on the intermediate nucleus, more hydrogen and less helium is emitted as the charge on the intermediate nucleus becomes higher.

The principal experiments on disintegration by fast neutrons are those of Feather; Harkins, Gans and Newson; Meitner and Kurie.

Remarkable work on the scattering of neutrons has been carried out by Dunning and his collaborators.

(14) Slow Neutrons

At the present time practically all neutrons as they are initially produced have very high velocities, that is velocities expressed as thousands of miles, up to 30 thousand miles, per second. This is because they are produced from heavy hydrogen, beryllium, boron or some other atom with a high decimal mass. This gives a large amount of mass available for conversion into kinetic energy. The only chance for slower neutrons to be ejected is for a part of this mass to be converted into a photon (gamma-ray energy).

The question arises: how can these fast neutrons be slowed down? The obvious answer is by collisions with other nuclei. If, however, they are not slowed down rapidly, they may be captured by some of the nuclei before their velocity becomes low. Thus the problem is solved by passing neutrons through material which will slow them down the most rapidly. Now it is a well-established relation of mechanics

that in an elastic collision between a light body in motion and a heavy body at rest, only a small part of the kinetic energy of the light body is given to the heavy one.

Thus lead, with heavy atoms, slows down neutrons very slowly, while hydrogen, with atoms of the same mass as the neutron, slows them down very rapidly.

In elastic collisions both the momentum (MV) and the kinetic energy ($\frac{1}{2}$ MV^2) of the two particles are kept constant. The equations for the maximum velocity imparted have already been given.

The maximum velocity imparted to a hydrogen atom (U_H) is

$$U_H = \frac{2M}{M+1} V = V$$

and to a lead atom (U_{lead})

$$U_{lead} = \frac{2M}{M+217} V = \frac{1}{104} V$$

and the kinetic energies are

$$E_H = \tfrac{1}{2} V^2$$

$$E_{lead} = \tfrac{1}{2} \times 207 \left(\frac{V}{104}\right)^2 = .00957 V^2$$

$$= \frac{1}{207} V^2$$

Thus it is possible for a neutron to lose practically all its kinetic energy in a single collision with a hydrogen nucleus, but it can not lose as much as a thousandth of its energy in a single collision in lead. Thus in lead it is usually captured before it has become slow.

These relations have been recognized since the earliest work was done on the scattering of neutrons in gases which contain hydrogen, but attracted general attention only after the remarkable behavior of slow neutrons was discovered.

If another solar system should pass through our own with a sufficiently high velocity, then barring too close approach of the bodies (suns and planets) themselves, the effects on both systems could be negligible. A slow passage would, however, produce very disastrous effects, since sufficient time would be given for the forces to act.

If, when a neutron passes moderately close to a nucleus in its passage through an atom, and if there is an attraction between the nucleus and the neutron, then the chance that the neutron be captured should increase with the time of interaction of the forces, that is as the velocity decreases. From this point of view slow neutrons should be captured much more often than the fast ones. This simple deduction has had ample experimental verification, although its quantitative form, that the chance of capture varies inversely as the velocity, is only approximately true. Not only are slow neutrons captured more frequently, but they are also more often deviated from their straight line path when they pass close to an atomic nucleus. That is both the absorption and the scattering of neutrons are greatly increased when the neutrons are made slow.

The customary method of expressing this is to say that in nuclear encounters the cross section of the neutron is much greater for slow than for fast neutrons, but not in the same ratio for capture and for scattering.

When the neutron was first discovered there seemed to be no possible means of protecting any region, close to a source of neutrons, from their great penetrating action. Now this can be done by putting up a wall of water or paraffin, either of which contains hydrogen. Such a wall converts the fast neutrons into slow ones. When the farther side of the wall is covered with a sheet of cadmium about a millimeter thick or a similar thickness of boron which absorbs the neutrons since the nuclei of these two elements, as well as those of a few others, attract slow neutrons at remarkably great distances as compared with other nuclei.

Thus, even near a powerful source of neutrons a room surrounded by such a wall is almost free from neutrons.

The work of Fermi on slow neutrons is discussed in the section on artificial radioactivity.

(15) The Hydrogen Nucleus or the Proton as a Projectile

On account of the positive charge on the hydrogen nucleus or proton it is repelled, except at very minute distances by an atomic nucleus. Thus only fast protons are able to come into contact with a nucleus. The principal reactions of protons ($_1H^1$) are given below as represented by specific disintegrations. The most general reaction is for a hydrogen nucleus to go in and a helium nucleus to come out, as

$$_9F^{19} + {}_1H^1 \rightarrow {}_{10}Ne^{*20} \rightarrow {}_8O^{16} + {}_2He^4 \qquad (1)$$

If the target is carbon this may be converted into radioactive nitrogen 13, which disintegrates directly into a carbon nucleus of mass 13 with emission of a positive electron (ε^+) with a half period of 10.3 minutes.

$$_6C^{12} + {}_1H^1 \rightarrow {}_7N^{*13} \rightarrow {}_6C^{13} + {}_1\varepsilon^0 \qquad (2)$$

In a reaction of type (1) the intermediate nucleus, represented above by $_{10}Ne^{*20}$, always breaks up into a helium nucleus and the remainder or residue of this nucleus. This residue is in some cases a new isotype of great interest to workers in this field. Thus with lithium of mass 6

$$_3Li^6 + _1H^1 \rightarrow _4Be^{*7} \rightarrow _2He^3 + _2He^4$$

a new lighter isotope of helium of mass 3 is formed, while with beryllium 9 both a new isotope of beryllium, of mass 8, and heavy hydrogen ($_1H^2$) are formed.

$$_4Be^9 + _1H^1 \rightarrow _5B^{*10} \rightarrow _4Be^8 + _1H^2$$

(16) Heavy Hydrogen (Deuterium) as a Reagent in Nuclear Chemistry

During the last two years deuterium has been the most widely used reagent in nuclear chemistry. That this is true is due to the remarkable combination of characteristics outlined below. Much of this work has been done by Lawrence and his collaborators, who have obtained deuterons with energies as high as six million volts. Crane and Lauritsen, in Pasadena, and the workers in Cambridge, England, have done important work, but with a much lower kinetic energy of the projectiles. The work of Tuve and Hafsted has been of interest, both with deuterons and with protons.

(1) The positive charge on the deuteron causes it to be accelerated in an electrical, and if in motion in a magnetic, field.

(2) The smallness of its charge, equal to that of the proton, enables it to penetrate the potential wall of a nucleus more easily than more highly charged positive particles, and in this it is excelled only by the neutron.

(3) The deuteron is a loose combination of a neutron (n) and a proton (p), of formula (pe), while the general formula for any nucleus is $(pe)_Z\ n_I$ in which Z is the atomic, and I the isotopic number. In the reaction, which has not been demonstrated to occur,

$$-{}_1^1H^1 + {}_0^1n^1 \rightarrow {}_1^0H^2 + E \qquad (1)$$
$$1.0081 + 1.0084 = 2.0142 + 0.0023$$

the energy of binding would be only 0.0023 or 2.15 MEV, which indicates that a single proton and a single neutron are only loosely bound, in the nuclear sense, in the nucleus of the atom of heavy hydrogen.

(4) The energy of combination of the deuteron with another nucleus, particularly if the atomic number is low and odd, is very high. Thus with itself, where E is the kinetic energy:

$$({}_1^0H^2 + {}_1^0H^2 + E \rightarrow ({}_2^0He^4 + (Q)) + E) \qquad (1)$$
$$2.01449 + 2.01449 + E \rightarrow (4.00336 + 0.02562) + E$$

Thus, unless the helium nucleus disintegrates or gives off a gamma ray, it must hold 0.02562 grams or 23.9 million electron volts (MEV) of excess energy. This causes it to disintegrate by (3) or (4)

$${}_2^0He^{*4} \rightarrow {}_1^1H^3 + {}_1^{-1}H^1 + Q \qquad (3)$$
$$4.02898 \rightarrow 3.01664 + 1.00807 + 0.00427$$

$${}_2^0He^{*4} \quad {}_2^{-1}He^3 + {}_0^1n^1 + Q \qquad (4)$$
$$4.02898 \quad 3.01664 + 1.00885 + 0.00339$$

The reaction between boron 10 and deuterium to give carbon 12 gives a carbon atom of mass 12.0290, which can not exist with its great excess of 23.7 MEV of energy so it disintegrates in one of three ways: (1) gives off a proton, (2) gives off a neutron, or (3) breaks up into 3 alpha particles (presumably in two steps).

By (3) the deuteron can give either (a) a proton or (b) a neutron to another nucleus. In (a) a charged particle must penetrate the other nucleus; in (b) the neutron may be captured and the charged particle escape. In (a) the charge of the other nucleus must be low unless the deuteron has an extremely high velocity, in (b) the charge may be either low or high since the neutron has no charge, (theory of Oppenheimer).

(17) Artificial Radioactivity

According to the point of view of this address, all nuclear disintegration is due to a radioactivity of the unstable intermediate nucleus.

The term artificial radioactivity has been used by others in a more specific sense to represent the possession of radioactivity of a measurable period by one of the products of a nuclear synthesis, and is commonly of the type in which a positive or negative electron is emitted, although the term includes delayed emission of γ-rays.

The first artificially radioactive atom to be discovered was nitrogen of mass 16 produced by action of a neutron, found by Harkins, Gans and Newsom, who assumed that it would give a delayed emission of a negative electron and change into oxygen 16. Although this was later proved to be true, the amount of material available was too small to demonstrate this at the time.

Curie and Joliot, by use of a large amount of polonium, were able to produce a different type of radioactivity, from α-rays, in sufficient quantity to give a direct experimental proof. Their work is of great importance, since they were the first to produce atoms of negative isotopic number.

Fermi, Amaldi, Agostino, Rosetti and Segre produced a large number of radioactive nuclei by the action of neutrons as in the experiment of Harkins, Gans and Newsom, and found slow neutrons to be specially effective in giving the property of radioactive emission of negative electrons or γ-rays to the atoms of almost any element.

It is well known that considerable amounts of radioactive sodium has been obtained by Lawrence by deuteron bombardment in a cyclotron.

Since a neutron in a nucleus when it changes to a proton emits a negative electron, and since a positive particle always contains at least one proton, and this

may change to a neutron and a positive electron, the following relations are what is to be expected whenever an electron is emitted.

1. When a neutron is captured the radioactive disintegration gives a negative electron.
2. When a proton is captured a positive electron is emitted.
3. When deuterons or α-particles are captured either a positive or a negative electron is emitted.
4. In electron emission the isotopic number does not fall below zero.
5. When a positive electron is emitted the isotopic number rises to +1 or higher.
6. A low isotopic number, as compared with the position of the band of stability, favors the emission of a positive, and a high isotopic number, the emission of a negative electron.

At the present time almost any element may be produced in a radioactive form, and it is probable that some or many of these will be useful in medicine and surgery. The effects of neutrons upon tissues should be much more intense than those of γ-rays. On account of the large water content of the body fast neutrons which penetrate the tissues are rapidly converted into slow neutrons, which are then captured. Thus nuclear chemistry enters the realm of physiology.

OBITUARY

CHARLES VELMAR GREEN

ON April 18, 1936, two days after his thirty-fourth birthday, Charles Velmar Green, a research associate and one of the Board of Directors of the Roscoe B. Jackson Memorial Laboratory, was accidentally drowned while fishing near Bar Harbor, Maine.

This sudden end to an all too brief career, marked by superior ability and great industry, had in it elements of tragedy lacking in the foreseen termination of the activities of those of advanced age.

The years of quiet, patient effort that had marked Green's progress from his birthplace on a farm in Ashley, Michigan, through school, Michigan State College and the University of Michigan, left their mark on his character. They had been distinguished throughout by self-reliance and independence of thought, by tenacity of purpose and by the highest ideals of personal integrity.

When in 1927, two years after his B.S. degree, he received an M.S. under the friendly guidance of Professor Harrison Hunt, of Michigan State College, he had already developed a calm maturity of intellect and an unfailing soundness of scientific judgment far in advance of his years.

These qualities he continued to show in increased measure during the work for his doctorate and in the years which followed it (1930–36). By concentration and tireless effort he obtained and analyzed a sufficient mass of data to establish for the first time linkage between genes for size and a gene for color in mammals. His grasp of this subject was demonstrated, not only in the initial presentation of his results but in the extended discussion of them which followed.

In the course of the development of his work he also contributed notably to research in the field of differential growth, to changes in crossing-over correlated with age and to many other interesting and important phases of mammalian genetics. He had already published more than thirty scientific papers covering a wide range of research.

His chief happiness lay in research rather than in teaching. Each succeeding year saw broader and more important advances in his methods of approach. To these advances two factors contributed greatly. One was the contentment and inspiration of his home life and the completely adjusted companionship with his wife, Sybil Kent Green. The other was the joy that he derived from fishing and other recreation inherent in the environment of Mount Desert Island.

One may fairly say that happiness, creative activity and a balanced integration of purpose filled his own life so abundantly that, to an unusual degree, he transferred these qualities to those around him. In the face of these inspiring facts the deep personal sorrow of his friends and associates must quickly be recognized as selfish, and must give place to a willing determination to carry on as he would have done had he lived.

C. C. L.

SCIENTIFIC EVENTS

THE BRITISH NATIONAL HUMAN HEREDITY COMMITTEE

A LETTER to the editor of the London *Times* of May 6, signed by R. Ruggles Gates; Humphry Rolleston; Grafton Elliot-Smith; R. A. Fisher; Arthur Keith; E. Farquhar Buzzard; Moynihan; F. Gowland Hopkins, members of the British National Human Heredity Committee (115 Gower Street, London, W. C. 1), reads as follows:

Problems of national health have reached a point where the hereditary element can no longer be neglected. The leaders of the medical profession are no longer satisfied with the alleviation of disease, but are acutely conscious of the need for fuller knowledge of heredity in connection

with its prevention. This applies not only to preventing the transmission of defects. It is recognized that methods of cure must vary with the type of constitution of the patient, and in this connection information concerning heredity is of great importance. In education, in training, and in choice of career, the ascertainment of innate endowment not only prevents waste and failure but would contribute largely to the attainment of success.

The instructed public already recognize the importance of heredity for the future of the race, and the Brock Report in 1933–34 emphasized the need for greater knowledge in regard to the inheritance of mental and physical defects. But there is as yet no center to which the public can turn for full information.

The Imperial Bureaux of Plant Genetics (in Cambridge and Aberystwyth) and of Animal Genetics (in Edinburgh) have achieved much by setting up simple machinery for collecting information based on the results of research and making these available for the practical breeder. The Bureau of Human Heredity which has recently been set up at 115, Gower Street, W.C.1, follows these models, and small contributions have already been made for its upkeep.

In these days of international mistrust and animosity, it is refreshing to find a field in which representatives of nearly every civilized nation are engaged in cooperative work. The scheme for an international clearing house of facts concerning human heredity has been evolved by a small international committee, which has delegated to its British members the task of setting up a bureau in London for the collection and distribution of all authentic information on human genetics. The British Council is asking for £10,000 to carry on this work for five years.

It is strange to think that students of fruit-flies, or mice, have at their command the latest information, while those similarly concerned with man can look nowhere for a complete survey of the knowledge they require.

The urgency of this need leads us to commend the Bureau of Human Heredity to public-spirited donors. They will find no institution the endowment of which will give a more liberal return for all time.

THE SUMMER SYMPOSIUM ON THEORETICAL PHYSICS AT THE UNIVERSITY OF MICHIGAN

PROFESSOR W. HEISENBERG, of Leipzig, who had planned to lecture on nuclear physics throughout the symposium on theoretical physics at the University of Michigan, has found it impossible to be at Ann Arbor this summer.

As finally arranged the program of the conference, which will last from June 29 to August 21, is as follows:

Professor E. O. Lawrence, University of California, "The Design and Technique of Cyclotrons, Artificial Radioactivity, the Biological Action of Neutrons and Other Similar Topics." For one month beginning June 29.

Professor P. Ewald, Technische Hochschule, Stuttgart, Germany, "The Theory of the Solid State." Throughout the session.

Professor H. Bethe, Cornell University, "The Physics of High Speed Particles." For one month beginning June 29.

Professor E. U. Condon, Princeton University, "The Quantum Mechanical Treatment of Selected Problems from the Field of Spectra." For six weeks beginning July 6.

Professor G. Breit, University of Wisconsin, "Special Topics in Nuclear Theory." For two weeks after July 20.

Professor I. Rabi, Columbia University, "Nuclear Moments." For two weeks after July 12.

Professor D. M. Dennison, University of Michigan, "Theory of Band Spectra." Throughout the session.

Professor Otto Laporte, University of Michigan, "Quantum Mechanics and Atomic Structure." Throughout the session. "Spinor Analysis." Two or three lectures.

NATIONAL RESEARCH FELLOWSHIPS IN PHYSICS, CHEMISTRY AND MATHEMATICS

THE Fellowship Board in Physics, Chemistry and Mathematics of the National Research Council announces the following appointments to Fellowships for 1936–37. After the name, the institution is given from which the doctorate was received (followed in the case of reappointments by the name of the institution at which the Fellow will work) and the subject of his research.

REAPPOINTMENTS FOR A SECOND YEAR

In Physics:

Albertson, Walter Edward, Massachusetts Institute of Technology '35, Mt. Wilson Observatory, "Spectroscopic Analysis."

Nordsieck, Arnold Theodore, California '35, Stanford University, "Relativistic Quantum Theory."

Van Voorhis, Stanley Nichols, Princeton '35, University of California, "Nuclear Physics."

White, Milton Grandison, California '35, Princeton University, "Construction of a Cyclotron for Nuclear Physics Research."

In Chemistry:

Bonner, Lyman Gaylord, California Institute of Technology '35, Princeton University, "Spectroscopic Determination of Molecular Structure."

King, Gilbert William, Massachusetts Institute of Technology '35, Harvard University, "Vibrational Levels of Polyatomic Molecules."

In Mathematics:

Levinson, Norman, Massachusetts Institute of Technology '35, Princeton University and Institute for Advanced Study, "Closure and Entire Functions. Tauberian Theorems."

NEW APPOINTMENTS

In Physics:

Konopinski, Emil John, Michigan '36, "Nuclear Theory."

Nier, Alfred Otto Carl, Minnesota '36, "Systematic Study of the Isotopic Constitution of the Elements."

Wooldridge, Dean Everett, California Institute of Technology '36, "An Investigation of the Nuclear Properties of Some of the Rare Gaseous Isotopes."

Yearian, Hubert Jose, Purdue '34, "Intensity Measurements in Electron Diffraction."

In Chemistry:

Adelson, David E., Florida '35, "Polycyclic Hydrocarbons Derived from Retene."

Beach, John Y., California Institute of Technology '36, "The Investigation of Molecular Structure by the Electron Diffraction Method."

Lord, Richard Collins, Jr., Johns Hopkins '36, "The Raman Spectra of Compounds of Deuterium."

In Mathematics:

Dribin, Daniel Maccabaeus, Chicago '36, "Arithmetic of Quadratic Forms."

Fialkow, Aaron, Columbia '36, "Geometric Characterization and Classification of Single-Parameter Families of Plane Curves."

Jacobson, Nathan, Princeton '34, "Pseudo-linear Transformations. Abstract Derivatives and Lie Algebras. Hypercomplex Numbers."

Tompkins, Charles Brown, II, Michigan '36, "Phases of Differential Geometry."

F. K. RICHTMYER,
Secretary

AWARD OF THE CHANDLER MEDAL TO PROFESSOR GIAUQUE

THE Charles Frederick Chandler Medal of Columbia University was presented on May 28 to Professor William Francis Giauque, of the University of California, discoverer of a method of magnetic cooling by which temperatures approaching absolute zero can be obtained.

Dr. George B. Pegram, acting dean of the graduate faculties of the university, presented the medal to Professor Giauque at a gathering of scientific men in Havemeyer Hall. Professor Giauque, who has made a systematic study of very low temperatures and entropy measurements, delivered the medal address on "The Production and Use of Temperatures Below One Degree Absolute."

In his address Dr. Pegram said that Professor Giauque's work "beautifully illustrates the power of experimental skill and ingenuity when directed by keenest appreciation of the guidance afforded by theory. A leader among those chemists who have with great effect been applying modern quantum theory to thermodynamic investigation, he has contributed to the more unified view of nature that chemistry and physics are achieving."

Professor Giauque's most extensive investigations have consisted in the extremely accurate determination, from 0.24 degree above absolute zero to room temperature, of the specific heats and heats of transition of hydrogen chloride, hydrogen bromide, hydrogen iodide, oxygen, nitric oxide and hydrogen. From these he has calculated the entropy of each of these gases. He has also been the first to calculate, from spectroscopic data for the same gases, entropy values which are more accurate than those based on the measurements of specific heats.

Professor Giauque stated in his address that "the results of these investigations have given strong support to the validity of both the third law of thermodynamics and quantum statistics. This type of work is largely responsible for the present confidence in the reliability of the many free energies of gases which have been very accurately determined by the application of quantum statistical methods to detailed spectroscopic observations."

The Chandler Medal, awarded annually by the trustees of Columbia University for conspicuous work in the field of chemistry, was established in 1910 in honor of the late Dr. Charles Frederick Chandler, a founder and president of the American Chemical Society, pioneer in industrial chemistry and professor at Columbia from 1864 to 1925.

Professor Giauque was born in Niagara Falls, Ontario, on May 12, 1895. He was graduated from the University of California in 1920, and held a fellowship there during the next two years, taking the doctor's degree in 1922. After five years as instructor, he was named assistant professor at California in 1927, associate professor in 1930 and full professor in 1934.

In 1929, following the announcement by Professor Giauque and Dr. Johnston of two new isotopes of oxygen, Professor Giauque shared the Pacific Division prize of the American Association for the Advancement of Science for the most important scientific contribution reported by a resident of the Pacific Division at its June meeting. He is a member of the American Chemical Society and a fellow of the American Physical Society. He has been vice-president of Commission XI of the Institut International du Froid since 1928.

The committee of award was composed of Professor A. W. Thomas, chairman; Dr. Leo H. Baekeland and Professor Arthur W. Hixson.

Former medalists include: L. H. Baekeland, W. F. Hillebrand, W. R. Whitney, F. G. Hopkins, E. F. Smith, R. E. Swain, E. C. Kendall, S. W. Parr, Moses Gomberg, J. A. Wilson, Irving Langmuir, J. B. Conant, G. O. Curme, Jr., J. G. Lipman.

IN HONOR OF PROFESSOR HERBERT OSBORN

AT the commencement exercises of the Ohio State University the doctorate of laws will be conferred on

Dr. Herbert Osborn, research professor emeritus of entomology, and the doctorate of science will be conferred on Dr. Ralph D. Mershon, engineer and inventor, New York City, and on Dr. Roy D. McClure, surgeon-in-chief at the Henry Ford Hospital, Detroit. In awarding the degree to Professor Osborn the faculty committee on honorary degrees writes:

> Professor Osborn has been the most successful teacher in the world on economic entomology, as judged by the number and success of his students.
>
> He has made this university known internationally as a center for this sort of training, and men have come to work with him from as far away as South Africa. His students are scattered over the globe, teaching and doing administrative and other work in South America, Japan, India, Australia, and Africa.
>
> Born at Lafayette, Wis., Professor Osborn is a graduate of Iowa State College. He has honorary degrees from that school and from the University of Pittsburgh in recognition of his scientific achievements. While located in Iowa, he was a faculty member at the state college, entomologist at the experiment station, later state entomologist, and president of the Iowa Academy of Science.
>
> Coming to Ohio in 1898 as a member of the university faculty, he also became director of the university's Lake Laboratory and director of the Ohio Biological Survey.
>
> He has served as consulting entomologist for the Maine experiment station and for the Tropical Plant Research Foundation, he is a past vice-president of one of the sections of the American Association for the Advancement of Science, and was for 20 years editor of the *Annals* of the Entomological Society of America.
>
> Professor Osborn is a past president of the Entomological Society of America, the Association of Economic Entomologists, the American Microscopical Society, the Ohio Academy of Science, the Society for the Promotion of Agricultural Science, and a member of numerous other groups.
>
> He has written several books and nearly five hundred papers for scientific journals of the United States and Europe. Since 1938 he has held the rank of professor emeritus at Ohio State.

AWARD OF THE TWO HUNDRED AND FIFTY THOUSANDTH BAUSCH AND LOMB MICROSCOPE TO PROFESSOR NOVY

DURING the spring of this year the Bausch and Lomb Optical Company manufactured its 250,000th microscope, the culmination of sixty years of endeavor, the first completed microscope having been shown at the Philadelphia Centennial Exposition in 1876. Recognizing its debt to American scientific men and educators who have been so helpful in the development of its microscopes, the company decided to award this instrument to an American scientist who had made outstanding contributions to science through researches with the use of the microscope. The company asked the American Association for the Advancement of Science to name one who in their estimation deserved this distinction.

A committee chosen by the association agreed unanimously in selecting Dr. F. G. Novy, professor of bacteriology and chairman of the executive committee of the Medical School of the University of Michigan. The presentation of the award will be made by Edward Bausch, chairman of the board of directors of the Bausch and Lomb Company, at a complimentary luncheon given to members of the American Association at the Rochester meeting on June 18.

This occasion will be the fiftieth anniversary of Dr. Novy's graduation from the University of Michigan and his entrance into scientific work. During the past fifty years, Dr. Novy, as an investigator and as a teacher, has contributed liberally and significantly to the development of bacteriology. Following his graduation from the University of Michigan, he pursued graduate studies there until 1888, at which time he went to Berlin and spent a year studying in the laboratory of Robert Koch. He is one of the very few living Americans who have had this privilege. He then returned to the University of Michigan to introduce instruction in bacteriology for medical students, and to continue graduate studies, receiving the degrees D.Sc. and M.D. in 1890 and 1891.

Thus, with training in chemistry, medicine and bacteriology, Dr. Novy was exceptionally well prepared to carry out bacteriological investigations. Immediately, he was recognized for his studies concerning the chemistry of bacteria, ptomaines, leucomaines and nucleins. The etiology of diphtheria, yellow fever and plague also received his attention. He developed techniques for the cultivation of anaerobic bacteria and discovered new species of anaerobes. Public health problems received his constant attention, especially the use of antitoxins and the practice of disinfection. In many of his investigations, the microscope was used continually, for example, in the study of trypanosomes and hematozoa of birds, mosquito flagellates, relapsing fever spirochetes and Leishman-Donovan bodies.

During two generations, Dr. Novy has instructed and inspired thousands of medical students in bacteriology and public health.

This microscope which is to be presented to Dr. Novy embodies the very latest features of research microscope design. It is of the reversed type, the arm being in front of the instrument so as to give free access to the object, stage, objective, sub-stage and mirror, and thus offering greater convenience and comfort to the user. In order to provide extreme rigidity, the inclination joint has been eliminated. This general design was suggested by Dr. Lester W. Sharp, of Cornell University, and his associate, Dr. L.

F. Randolph, of the United States Department of Agriculture and Cornell University.

Following the presentation of the award at the luncheon, Dr. Novy will give an address on "Some Results of Microscopic Research Which have been of Significance for Human Welfare."—*A Correspondent.*

SCIENTIFIC NOTES AND NEWS

THE retirement is announced of Dr. T. Wayland Vaughan, director of the Scripps Institution of Oceanography of the University of California. He will be succeeded by Dr. Harald Ulrik Sverdrup, Norwegian oceanographer and meteorologist, since 1928 research associate of the Carnegie Institution of Washington. Dr. Sverdrup has spent a number of years in the Arctic, having been a member of the Norwegian North Pole expeditions on the *Maud,* from 1917 to 1925.

DR. RICHARD GOLDSCHMIDT, formerly department head at the Kaiser Wilhelm Institute for Biology in Dahlem, Germany, has been appointed to a professorship in the department of zoology of the University of California. As has been noted in SCIENCE, Dr. Charles Atwood Kofoid, for many years head of the department, retires at the close of the present academic year.

DR. WILLIAM E. CASTLE, of Harvard University, has retired and will become professor emeritus in September. Dr. Castle was appointed instructor in zoology in 1897 and became professor in 1908.

THE retirement is announced of Dr. Edward R. Cary, professor of geodesy and road engineering at the Rensselaer Polytechnic Institute. He has been a member of the faculty for forty-eight years.

DR. CHARLES MURRAY, head of veterinary research at Iowa State College, has been appointed acting dean of the Division of Veterinary Medicine, thus filling the vacancy created by the death of Dean C. H. Stange.

DR. H. J. MULLER, who has been on leave of absence for the past four years, has resigned from the faculty of the University of Texas. He has spent the last three years with the Russian Academy of Science, now at Moscow, and plans to continue his work in that institution.

DR. PETER DEBYE, professor of experimental physics at the University of Leipzig, has been called to a professorship in the University of Berlin.

THE honorary degree of LL.D. of the University of St. Andrews will be conferred at the graduation ceremonial to be held in June on Dr. J. E. Littlewood, Rouse Ball professor of mathematics at the University of Cambridge, and on Dr. E. W. Reed, emeritus professor of physiology at University College, Dundee.

ON the occasion of the visit of the British Medical Association to the University of Oxford the honorary doctorate of science will be conferred on Sir George Newman, formerly chief medical officer of the British Ministry of Health; on Sir Cuthbert Wallace, of the Radium Commission, president of the Royal College of Surgeons; on Sir Henry Dale, director of the British National Institute for Medical Research; on Sir Walter Langdon Brown, formerly regius professor of physic at the University of Cambridge; on Dr. Robert Hutchison, consulting physician, London; and on Dr. Charles Singer, professor of the history of medicine at the University of London.

THE Royal College of Physicians, London, has elected to fellowship Sir Frederick Banting, professor of medical research at the University of Toronto; Dr. Robert T. Leiper, Courtauld professor of helminthology at the University of London, and Dr. Havelock Ellis.

THE honorary degree of doctor of engineering was conferred on E. T. Stannard, president of the Kennecott Copper Corporation, and on Louis S. Cates, president of the Phelps Dodge Corporation and a vice-president of the American Institute of Mining and Metallurgical Engineers, at the fiftieth anniversary graduation exercises on June 4 of the Michigan College of Mining and Technology, Houghton. Mr. Stannard gave the commencement address.

THE Lamme Medal, presented each year during the commencement of the Ohio State University in recognition of achievement in engineering, has been awarded to Ervin G. Bailey, vice-president and director of the Babcock and Wilcox Company of New York, manufacturers of water-tube boilers.

THE Henry Laurence Gantt Gold Medal of the American Management Association has been awarded "for distinguished achievement in industrial management as a service to the community" to Morris E. Leeds, president of the Leeds and Northrup Company, Philadelphia, Pa. This medal has been given annually since 1929 by the Institute of Management, the research group of the association, to individuals selected by a committee of award, half of whom are appointed by the institute and half by the American Society of Mechanical Engineers. Last year the recipient was Arthur H. Young, vice-president in charge of industrial relations of the United States Steel Corporation. The presentation of the medal to Mr. Leeds was

made at a dinner on June 4 at the Hotel Astor, New York, by Henry S. Dennison, president of the Dennison Manufacturing Company, Framingham, Mass., who was awarded the Gantt Medal in 1932. Harold B. Bergen, president of the institute, will preside.

Industrial and Engineering Chemistry writes that Erik Nielsen, research chemist at the Miner Laboratories, Chicago, Ill., has received notification from Denmark that he has been awarded a prize by the Industriraadet. Certain members of the Industriraadet have furnished funds to serve as prizes for the best suggestions with regard to increase of gainful employment of Danish workmen by means of new uses for Danish materials. In competition with 463 other contestants, Mr. Nielsen was awarded the 3,000-crown third prize for a suggestion pertaining to industrial use of apple pectin.

PROFESSOR M. T. MUNN has been put in charge of a new research division, to be known as the Division of Seed Investigations, which has been established at the New York State Experiment Station at Geneva. The division will handle the official seed inspection and will conduct researches into the physiology of germination, various phases of the problem of seed-borne diseases and other investigations pertaining to seeds.

PROFESSOR EUGENE D. MONTILLON, of the department of landscape architecture at Cornell University, has been appointed to the Ithaca City Planning Commission, succeeding Dean Dexter S. Kimball, of the College of Engineering, who has resigned. Dr. Ralph S. Hosmer, professor of forestry, is chairman of the commission.

DR. OTTO EGGERT, professor of geodesy at the University of Berlin, has been appointed director of the Geodetic Institute at Potsdam to succeed Dr. Ernst Kohlschütter.

GRANTS from the Committee on Scientific Research of the American Medical Association have been made to Dr. Philip Levine, bacteriologist at the Beth Israel Hospital, Newark, N. J., to aid him in his work on the "Specific Action of Bacteriophage in the Dysentery Group"; to Dr. Fae Donat Wood, of the department of zoology of the University of California at Los Angeles, toward a study of the distribution and virulence of *Trypanosoma cruzi*, the causative agent of American human trypanosomiasis in the southwestern United States, and to Dr. Robert H. Gault, director of the American Institute for the Deaf-Blind, for the continuance of work on the vibro-tactile senses.

DR. LUDWIG PINCUSSEN, formerly head of the biological laboratory of the Urban Hospital in Berlin, has been appointed research associate in the department of physiology of the College of Medicine of the University of Illinois, on a grant supplied by the Wander Company. He will work on the problem of chemical changes in relation to senescence, with particular reference to the influence of nutritional factors.

A COMMITTEE on the hygiene of housing, under the chairmanship of Professor C.-E. A. Winslow, of Yale University, has been created by the American Public Health Association. Other members of the committee include Rollo H. Britten, senior statistician, U. S. Public Health Service, Washington, secretary; A. R. Clas, director of housing, Federal Emergency Administration of Public Works; Colonel J. I. Connolly, of the Chicago Department of Health; Robert L. Davison, director of housing research, John B. Pierce Foundation, New York City; J. André Fouilhoux, architect, New York City; Miss Greta Gray, University of Southern California; Dr. James E. Ives, senior physicist, U. S. Public Health Service, and H. A. Whittaker, sanitary engineer, State Department of Health, Minneapolis. This committee will cooperate with groups interested in the hygiene of housing through the Health Section of the League of Nations.

THE twenty-third, or Templeton Crocker, expedition of the department of tropical research of the New York Zoological Society has returned. It was carried on under the directorship of Dr. William Beebe, who, together with three members of his staff, John Tee-Van, Miss Jocelyn Crane and George Swanson, were invited by Mr. Templeton Crocker as guests on his yacht *Zaca*. Two months were spent in the Pacific with prolonged stops at Cape San Lucas, Inez Bay in the Gulf of California and Clarion Island. Special objects of research were tunas, whale sharks, intensive dredging on the Punta Arena and Gorda Banks and as types of isolated oceanic islands, comparison of Clarion with Bermuda.

The Harvard Alumni Bulletin states that Dr. Thomas A. Jaggar, chief of the Section of Volcanology of the U. S. Geological Survey and now stationed at Kilauea Observatory, Hawaii National Park, has been invited by the Royal Society of London to accompany a mission to Montserrat, an island in the West Indies, in connection with the earthquake developments there. He started for the island several weeks ago, going by way of San Francisco, Jamaica and the Virgin Islands. He expects to be away about two months and to return to Hawaii by way of the state of Washington.

DR. T. G. YUNCKER, professor of botany at DePauw University, is conducting an expedition to central Honduras this summer for the purpose of making plant collections. Assisting him will be Ray Dawson, graduate student in botany at Yale University, and Howard Youse, senior botany student at DePauw

The party plans to land at Puerto Cortez, then proceed to Siguatepeque below Lake Yojoa, where several weeks will be spent collecting about Lake Yojoa and in the mountains about Siguatepeque.

DR. JAMES W. JOBLING, of the department of pathology of the College of Physicians and Surgeons, was in Puerto Rico during the month of April as representative of Columbia University at the annual meeting of the Special Board of Trustees of the School of Tropical Medicine at San Juan. Dr. C. U. Lee, of Peking Union Medical College, is now in Puerto Rico, where he plans to carry out certain investigations in diseases caused by parasites.

DR. E. C. AUCHTER, assistant chief of the Bureau of Plant Industry and principal horticulturist in charge, Division of Fruit and Vegetable Crops and Diseases, U. S. Department of Agriculture, addressed the chapter of Sigma Xi at Cornell University at the annual banquet on May 20, following the initiation of the newly elected members. His subject was: "Plant Research in the Department of Agriculture."

DR. MELVILLE J. HERSKOVITS, professor of anthropology at Northwestern University, addressed the University of Cincinnati chapter of Sigma Xi on "Race and Human Heredity" on May 19, on the occasion of the initiation meeting.

DR. GUY STANTON FORD, dean of the Graduate School of the University of Minnesota, and Dr. F. K. Richtmyer, dean of the Graduate School of Cornell University, were the principal speakers at the twenty-fifth anniversary of the Graduate School of the Ohio State University. Dr. William McPherson, professor of chemistry, has been dean of the school since its establishment. At the dinner in the evening Dr. George W. Rightmire, president of the university, was toastmaster. The speakers were Dean Fernandus Payne, of Indiana University, for the Association of American Universities; President Edmund D. Soper, of Ohio Wesleyan University, for the Ohio College Association, and Dean Daniel Luther Evans, of the College of Wooster, for the doctors of philosophy of Ohio State University.

A SYMPOSIUM on "Scientific Aspects of Flood Control," sponsored by the Ecological Society of America jointly with the American Association for the Advancement of Science, will be held in the Strong Auditorium of the University of Rochester at 3:00 P. M. on June 18. Dr. E. G. Conklin, president of the association, will introduce the presiding officer, Dr. W. S. Cooper, president of the Ecological Society. The field will be covered by three speakers, as follows: Dr. F. A. Silcox, chief, National Forest Service, "Forests and Flood Prevention"; Dr. W. C. Lowdermilk, associate chief, U. S. Soil Conservation Service, "Agricultural Land Use and Floods"; Dr. Morris L. Cooke, administrator, Rural Electrification Administration, "On the Relations of Engineering Science to Flood Control."

THE annual meeting of the American Society of Zoologists will be held with the American Association for the Advancement of Science in Atlantic City on Tuesday, Wednesday and Thursday, December 29, 30 and 31. Professor H. B. Goodrich, the secretary, writes: "This is a change from the original plan to meet in Washington. Investigations made by the American Association for the Advancement of Science indicated that in view of the early date of the national presidential inauguration it would be desirable to shift all scientific meetings elsewhere. A symposium on 'Studies in Experimental Populations' will be held on Tuesday afternoon. The annual dinner is scheduled for Wednesday evening. A number of special discussion sections in addition to the regular program are being arranged."

THE twenty-fifth congress of the Italian Society for the Advancement of Science will be held this autumn at Tripoli, under the presidency of Marshal Balbo, Governor of Libya.

Nature reports that the eighth International Congress of Theoretical and Applied Limnology, which was to have been held in Paris this year, has been postponed until 1937, when the world exhibition will take place.

THE series of meetings to be held under the auspices of the International Standards Association in Budapest this summer will take place during the two weeks beginning on August 31 and not on September 14, as tentatively announced.

THE second congress of the International Association for the Study of Solar, Terrestrial and Cosmic Radiations will be held at La Malou, Hérault, on July 15, 16 and 17.

APPLICATIONS must be on file with the U. S. Civil Service Commission, at Washington, D. C., not later than June 22 for the position of principal biochemist in the Bureau of Chemistry and Soils of the Department of Agriculture at a salary of $5,600 a year. Vacancies in this position in Washington, D. C., and in the field, and in positions requiring similar qualifications will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer or promotion. The salary named above is subject to a deduction of 3½ per cent. toward a retirement annuity. Competitors will not be required to report for examination at any place, but will be rated on their education and experience on a scale of 100.

IN cooperation with the Federal Office of Education, the Smithsonian Institution on Sunday, June 7, will inaugurate a series of radio broadcasts in the form of dramatic sketches dealing with its current scientific investigations and with the natural history, historical and other material in its collections.

THE first number of the new *Journal of Symbolic Logic* has recently appeared. The editors are Professors A. Church, of the department of mathematics at Princeton University, and C. H. Langford, of the department of philosophy at the University of Michigan. The journal is published by the Association for Symbolic Logic, whose secretary is Professor C. A. Baylis, of Brown University, and provides a means of contact between mathematicians and philosophers working in the field of symbolic logic.

The St. Louis Post-Dispatch states that a federal grant of about $12,000 a year to St. Louis County, in connection with the proposed reorganization of the County Health Department, has been approved by the United States Public Health Service. First steps under the plan will be appointment by the County Court of a new county health officer, who will supersede the present health commissioner, Dr. Edwin L. Sheahan; a director of sanitation and a superintendent of public health nurses, all of whom must be approved by the state and federal health services. Their salaries, paid from the grant, will be about $5,000 a year for the health officer; $3,200 for the director of sanitation and $2,400 for the superintendent of nurses. Each will receive also $600 a year for transportation expenses. On appointment, the three new officers will undertake the reorganization of the department according to standards fixed by the federal service. It is also reported that an additional $8,000 to $10,000 probably will be made available to the county by Washington University, which plans to open a department of public health in the medical school, probably next September, which would use the reorganized County Health Department as a training ground for students.

IT is reported in the daily press that the Swedish government plans to erect in Stockholm a medical center the cost of which is estimated at $10,000,000. It is stated that the main building will be H-shaped, with a roof for sun bathing, and will be seven stories high. It will contain operating theaters, lecture halls, wards and laboratories. In addition there will be a children's hospital, a building for psychiatry, rheumatism and cancer clinics, a swimming pool, football grounds, tennis courts, a church, concert halls, and home for staff doctors, students and nurses. The plans were originated in 1931 and work on roads and excavations started in 1932.

DISCUSSION

IS GEOLOGY A SCIENCE?

THE position of geology in relation to the sciences is an anomalous one. The so-called physical and biological sciences can be readily arranged in linear fashion passing from mathematics through astronomy, astro-physics, physics, chemistry and biology to anthropology, with the various branches of each clustered around a central position. Where, in this family of sciences, does geology logically belong? It is considered by some to belong in the physical science division, but its precise position is not obvious. In truth, by its use of facts and techniques from other sciences, geology is related, along part of its common boundary, to each of the fundamental sciences, and might, because of its dedication to learning the history of the earth, be placed in a central position, with the others around it. On the contrary, it may be judged by some as not strictly a member of the true family line, but merely a sort of peripatetic relative, going the rounds of more respectable abodes.

The writer has been led to wonder if the latter figure does not really represent a too common conception. He has seen a number of substantial histories of science in which geology is scarcely mentioned or, if mentioned at all, is named only in discussing some special theory, such as organic evolution, isostasy or the use of radioactive substances in determining the age of the earth. If there is a good history of science which deals with the growth of methods and understanding in geology at a length comparable to that bestowed on the other sciences, a reference to it would be appreciated. Of course there are several good histories of geology itself or of one or more of its branches.

Geology is primarily a field science, and despite its borrowing of methods from other sciences, its main reliance for learning the history of the earth is the collection, classification and logical interpretation of terrestrial facts, these mostly simple unembellished facts about kinds and relationships of rocks. Growth of science in the last few decades has involved an increasing precision and scope of laboratory measurements made on the greatly increased variety of materials and objects available for study. Compared to the swift change of some of the stunts of one decade into the standard procedures of the next in many of the sciences, the progress of geology is a plodding one, both figuratively and literally.

The doctoral candidate in physics works in an institutionally provided laboratory, often capably or bril-

liantly carrying on studies which are a part of the amazing advance of modern physics. The doctoral candidate in geology frequently ranges the same plains and mountains first viewed by the pioneers, not yet all traversed by automobile roads, and frequently is obliged to defer completion of his thesis for some years after completing residence requirements because of his difficulty in singlehandedly carrying on operations in a remote field. A few of our universities have helped to meet these primitive difficulties of geologic investigation by providing organized camps and the like. Many others, while freely providing the instruments and laboratories of physics and making research in this branch "physically" easy, have not only failed to sponsor field work in geology adequately, but have refused to accept as dissertation material work done under those competent national or state agencies which are giving institutional support to research in geology!

Such policies have diverted groups of able students to other universities having a more liberal policy in this regard. The ground has been taken by some universities and other fellowship agencies that "expeditions" should not be sponsored, while money for the purchase of laboratory equipment in other branches was freely offered and considered better spent. It appears that the glamor and news value and tangibility of laboratory or instrumental research has operated in some degree to the relative detriment of such prosaic work as deciphering the history of the earth.

It has been charged that benefactors of universities have been prone to build buildings which could be seen, but have rarely provided the means to maintain and operate them for the purpose stipulated. It is equally true that universities, foundations, and the like, have often been victims of the tendency to favor tangible and newsworthy, rather than necessarily fundamental, support and facilities for research. Thus a million dollars spent to learn more about the occurrence and origin of the ores of certain metals might result in a few books on ore deposits; a million dollars spent on an astronomical observatory would result not only in an equal number of books, but also in a magnificent telescope and an imposing building bearing the name of the donor.

Is it not quite obvious that the offering of some of our outstanding prizes for research tend to an overemphasis in spectacular fields? Science Service no doubt has some estimate of the relative newsworthiness of advances in various sciences, but even without such estimate we know that a fact can be the better "sold" if it has been captured by means of some instrument that is larger or smaller or more refined or more costly than its predecessors, or if its learning has involved the counting of a million or ten to any other n^{th} flies or atoms or the like. The writer knows dozens of geologists who have individually cracked off the outcrop enough rock specimens to build and fill a geological museum, but somehow, though we believe geologic information has value, few of us have been successful in making news capital out of the length, width, height and style of architecture of said museum.

Recently there has appeared the review of another book set forth as an ably compiled résumé of science. It was compiled by visiting outstanding laboratories, and it is the fear of the writer, though he has not seen the book and may be agreeably surprised, that the largest laboratory of all, that in which both geologic evolution and its understanding by man are worked out, was not included in the itinerary. Neither its processes nor the current methods for their interpretation, excepting perhaps the modern divining rods of geophysics, have the gadget appeal which seems so all-important to the public, and which we fear is not without its influence in circles closer to science.

And so we return with no real answer to the question as to whether geology is a science. But until we have an answer, might we not have "A New History of Science," including (or excluding) geology, which would at least not raise false hopes on the part of a perennially hopeful digger for terrestrial lore.

CHESTER K. WENTWORTH
BOARD OF WATER SUPPLY
HONOLULU, T. H.

A PLEA TO PUBLISHERS OF SCIENTIFIC BOOKS

EVERY scientist receives advertisements of many more forthcoming books than he can afford to purchase. My own recent practice has been to make a bibliographic card for each work in which I am interested and to file it so that it will be at least listed in my bibliography until finances permit, or necessity compels, the purchase of the volume. Frequently in making these cards I have been annoyed by the failure of the publisher to give the date of publication, the number of pages and other necessary details, even when the advertising brochure is elaborately printed and illustrated. Let us presume that several such incomplete cards, representing a given subject, are on file and that you wish to select from the titles available. On what basis can selection be made? The book can not be chosen on the basis of modernity, size or illustrative matter, for none of these facts is known. The alternative, of course, is to make a trip to the nearest library whenever a sufficient number of cards has accumulated and to fill in the missing data from the Library of Congress cards. Many of us naturally object to this expenditure of time in the search for the very information which the publisher should have supplied.

To satisfy my own curiosity as to the extent of this

practice, I prepared bibliographic cards for each of the last twenty-five book advertisements which I have received. As the twenty-five were not selected in any way, even this small series may be presumed to give a fair sampling of publishing practice. These brochures represented twelve leading publishing houses in the United States and Great Britain. In only *one* instance was a date given on the brochure itself, and in only three additional cases could the year of publication be inferred from a dated sales letter which accompanied the advertising folder. The number of pages was stated in eleven instances, but the number of illustrations was given only nine times. In every case the price of the book was mentioned, but I can recall having received advertisements in which even the price was omitted!

It is my considered opinion that the publishers of scientific books would sell more copies and would earn the gratitude of scientists by reducing the elaborateness of their brochures and by sending with each advertisement a 3 × 5 bibliographic card patterned after a Library of Congress card. I am aware that several American publishing houses now follow this practice, and I hope that the custom will become general. Many of us would take the trouble to file such cards where they would be available for reference, even though we might not be able to purchase many of the volumes. Every one has had the experience, I think, of being called upon to recommend a book in some borderline field and being unable to recall the author or title of a book which would exactly meet the request and about which one's only memory is that the bulky advertisement which called it to his attention was chucked into the waste basket some months previously.

Another valid complaint against publishers, I believe, is their almost uniform failure to send announcements of children's books in a given field to their mailing list of scientific workers in that field. Those of us who are located in museums are called on to recommend fully as many children's books as technical works. As the Christmas season approaches many a puzzled mother, anxious to cater to the strange tastes of her son, telephones to me for a list of popular books on reptiles, and only the kindness of a local library which allows me to preview each new herpetological children's title enables me to answer such inquiries.

M. GRAHAM NETTING

CARNEGIE MUSEUM

NOTICE OF POSSIBLE SUSPENSION OF RULES OF NOMENCLATURE IN CERTAIN CASES

ATTENTION of the zoological profession is invited to the fact that request for the "Suspension of the Rules" has been made in the following cases, on the ground that "the strict application of the Régles will clearly result in greater confusion than uniformity." According to procedure one year's notice is hereby published, "making it possible for zoologists, particularly specialists in the group in question, to present arguments for or against the suspension under consideration."

Note A.—Suspend rules.

Note B.—Insert in Official List with the type as given in parentheses.

COELENTERATA.—***Monograptus*** Geinitz, 1852 (***priodon***); A, B.

Retiolites Barrande, 1850 (***geinitzianus***); A, B.

Graptolithus Linn., 1768, to be suppressed; A.

ECHINODERMATA.—***Luidia*** Forbes, 1839 (***fragilissima***); A, B.

NEMATODA.—***Anguina*** Scopoli, 1777 (***Vibrio tritici***) to be suppressed; A.

CRUSTACEA.—***Squilla*** Fabricius, 1787 (***mantis***); A, B.

INSECTA.—The so-called "Erlangen List" of 1801 to be suppressed.

ORTHOPTERA.—***Locusta*** Linn., 1758 (***Gryllus Locusta migratorius*** Linn., 1758); ***Phaneroptera*** Serville, 1831 (***Gryllus falcatus*** Poda, 1761); A, B.

HYMENOPTERA.—***Cimbex*** Olivier, 1790 (***Tenthredo lutea*** Linn., 1758); A, B. ***Crabro*** Fabricius, 1775 (***Sphex cribraria*** Linn., 1767); A, B. ***Lasius*** Fabricius, 1805 (***Formica nigra*** Linn., 1758); A, B. ***Anthophora*** Latreille, 1803 (***Apis pilipes*** Fabr., 1775); A, B. ***Ichneumon*** Linn., 1758 (***Ichneumon extensorius*** Linn., 1758); A, B. ***Pimpla*** Fabr., 1804 (***Ichneumon instigator*** Fabr., 1793); A, B. ***Ephialtes*** Gravenhorst, 1829 (***Ichneumon manifestator*** Linn., 1758); A, B. ***Bracon*** Fabr., 1805 (***Bracon minutator*** Fabr., 1798); A, B. ***Pompilus*** Fabr., 1798 (***Pompilus pulcher*** Fabr., 1798); A, B. ***Bethylus*** Latreille, 1802 (***Omalus fuscicornis*** Jurine, 1807); A, B. ***Prosopis*** Jurine, 1807 (***Sphex signator*** Panzer, [1798]); A, B. ***Ceraphron*** Jurine, 1807 (***Ceraphron sulcatus*** Jurine, 1807); A, B. ***Torymus*** Dalman, 1820 (***Ichneumon bedeguaris*** Linn., 1758); A, B. ***Proctotrupes*** Latreille, 1796 (***Proctotrupes brevipennis*** Latreille, 1802); A, B. ***Sphex*** Linn., 1758 (***Sphex flavipennis*** Fabr., 1793); A, B. ***Ammophila*** Kirby, 1798 (***Sphex sabulosa*** Linn., 1758); A, B.

LEPIDOPTERA.—In interpreting the generic names assigned by Freyer in his ***Neuere Beiträge zur Schmetterlingskunde*** to the species there described, each species is to be regarded as having been described by Freyer as belonging to the genus cited by him at the head of each description and not to the genus with which he actually associated the specific name. For example, Freyer described, under the genus ***Hipparchia*** Fabricius, a species to which he gave the

specific name *eriphyle,* and which he proceeded to name *Papilio eriphyle* Freyer. Freyer is to be deemed to have described this species under the name *Hipparchia eriphyle* and not under the name *Papilio eriphyle;* A.

Potamis Hübner, *Rusticus* Hübner, and *Mancipium* Hübner to be suppressed in favor of *Morpho* Fabr., *Helicopis* Fabr., and *Pontia* Fabr.; A.

LEPIDOPTERA (RHOPALOCERA).—*Euploea* Fabr., 1807 (*Papilio corus* Fabr., 1793); A, B. *Satyrus* Latreille, 1810 (*Papilio actaea* Esper., [1780]); A, B. *Argynnis* Fabr., 1807 (*Papilio paphia* Linn., 1758); A, B. *Vanessa* Fabr., 1807 (*Papilio atalanta* Linn., 1758); A, B. *Euthalia* Hübner, [1823] (*Papilio lubentina* Cramer, 1777); A, B. *Nymphidium* Fabr., 1807 (*Papilio caricae* Linn., 1758); A, B. *Colias* Fabr., 1807 (*Papilio hyale* Linn., 1758); A, B.

Species in parentheses are to be declared the types: *Lycaeides* Hübner, [1823] (*Papilio argyrognomon* Bergstrasser, 1779); A. *Agriades* Hübner, [1823] (*Papilio glandon* Prunner, 1798); A. *Polyommatus* Latreille, 1804 (*Papilio icarus* Rottemburg, 1775); A. *Euchloë* Hübner, [1823] (*Euchloë ausonia* Hübner, var. *esperi* Kirby, 1871). *Princeps* Hübner, [1807] and *Orpheides* Hübner, [1823] (*Papilio demodocus* Esper, 1798). *Carcharodus* Hübner, [1823] and *Spilothyrus* Duponchel, 1835 (*Papilio fritillarius* Poda, 1761); A.

C. W. STILES,
Acting Secretary, International Commission on Zoological Nomenclature
U. S. NATIONAL MUSEUM
MAY 1, 1936

SCIENTIFIC BOOKS

THE MIGRATIONS OF ANIMALS

The Migrations of Animals from Sea to Land. 1936. By A. S. PEARSE. 176 pp., 4 figs. Duke University Press, Durham, N. C. $3.00.

THIS book expresses a philosophy, no less than an epitome of the researches of its writer and more than 500 other cited authorities into an intricate history. Animals which have struggled up the evolutionary trail from marine habitats to stand on dry land are the dominant ones of the earth. They have achieved success, which Professor Pearse defines as continual improvement. A successful creature is both plastic and progressive; it must live in the world as it is and yet with greater efficiency than its rivals, and must avoid the "soft berths" in which certain degraded forms may exist almost without struggle. On land animals have developed greatest power to solve complex problems. It is with the obstacles that have been met and conquered along the road between primitive aquatic associations and human civilization that this study is concerned.

After an introduction relating to the origin of life in the sea and a comparison of biotic conditions in salt and fresh water and ashore, the author develops his subject in four main chapters covering routes from sea to land, causes of the migrations, the changes in creatures that have crossed one of the several thresholds and a consideration of what land animals have attained. Always the physiological difficulties, requirements, mechanisms and adjustments are uppermost in his plan, and their elucidation makes both terse and rich reading. As nearly as possible the argument is developed in words condensed directly from the sources, and the text bristles with references. Such an eclectic method is not without its pitfalls; we encounter now and then the equal acceptance of more or less contradictory conclusions, as for instance Case's dogma that "environment changes before changes appear in organic forms" (p. 12), together with Banta's belief that "cave species are fitted for cave life before entering caves" (p. 33). Furthermore, Professor Pearse appears ultimately a bit uncertain as to just where he stands with regard to "adaptive" geographic changes. Are not all "adaptations," indeed, to be interpreted as "fortunate accidents," as is done with selected examples on pp. 85 and 115? Perhaps the genetic basis in the general problem of acclimatization might well have been further emphasized. The remark that subspecies "may be so stable that they will breed true for generations when isolated" is surely a marvel of understatement for every tested case.

As life on earth may have come into being on discrete occasions during a favorable stage in cosmic history, so too we find that complex yet diverse organisms later exhibit a marked parallelism in their biophysical responses at equivalent levels of altering environment. Between the extremes of the migration of which this book treats, for instance, the regulation of osmotic concentration and of respiration among various animals constantly calls for active processes in integument, glands, hormones, blood pigments, renal organs, gills, swim-bladder, etc. It is illuminating to learn of the general similarity, or even identity, of the resulting interactions. The gradual transition from aquatic to terrestrial life may be suggested by a series of fishes arranged according to the alkali reserve, *i.e.,* the bicarbonate content, of their blood. Within cer-

tain species-groups of littoral crustaceans that straddle the gap between water and air, we find a progressive reduction of gill volume in the same direction. In his chapter of nearly fifty pages on "changes," from which these examples are drawn, Professor Pearse presents a masterly review of many orders of animals under such headings as integument, respiration, body fluids, metabolism, locomotion, nervous system, excretion, reproduction, food and digestive organs, acclimatization and parasites.

It is very unfortunate that the editorial plane of a work of such consummate scholarship should be so far below its scientific standard. The reviewer has checked three or four times as many typographic errors as the 13 listed on the errata slip, and there is a bewildering discrepancy between the spelling of authors' names in text and bibliography, from the latter of which, by the way, at least a dozen authorities referred to by name and date are omitted altogether. Occasionally a misprint, as near the top of p. 115, has resulted in a meaningless sentence, and it is likely that one or more apparent errors of fact are in reality misprints. For example, the substitution of "common eel" for "conger eel" on p. 9 would make a false statement true. A few other factual details are open to question, such as the allegations that most species of salmon die after spawning and that the usual winter range of highly migratory birds is selected because of "more desirable" attributes. For the sanderling, New Jersey furnishes a no less optimum winter range than Patagonia, even though many more birds migrate to the latter than remain in the former.

The book lends weight to the tenet that the body fluids of the higher animals are still substantially isotonic with the primordial sea; that the migration from saline water to fresh and from the latter to air has been fought out against a steep respiratory gradient, and that "a film of aqueous liquid" has been carried throughout the course of evolution as the only respiratory medium. As a whole, the text, which is admirably lucid, serves up a concentrated "intellectual pemmican," with a challenge to further thought on every page, and with a capable summary, as well as a key to more detailed sources, in almost every paragraph.

ROBERT CUSHMAN MURPHY
AMERICAN MUSEUM OF NATURAL HISTORY

NORTH AMERICAN FOSSILS

Type Invertebrate Fossils of North America (Devonian), Unit 7b, Ammonoidea. By A. K. MILLER. Wagner Free Institute of Science, Philadelphia, 1936, 50 cards, 8″ × 11½″. $2.50, plus postage.

THE Paleontological Society and the Wagner Free Institute of Science have begun the publication of a great card catalog of the fossil invertebrates of North America. With this first unit of 50 cards they have set out to carry through one of the most ambitious programs of research and publication ever undertaken by students of the life of the past. If the paleontologists of North America can keep the future units of their catalog up to the high standard of the first one, their work will rank as a classic and they will have erected a milestone on the highroad of progress of their science.

The program calls for the preparation, by the specialists most competent to do the work, of cards for every species of North American fossil invertebrate, such cards to bear figures of the holotypes or cotypes of the species involved and condensed information about their distinctive characters, original places of description, type localities and occurrences and the locations of type specimens. The first unit, which is made up of the cards for the 50 species of Devonian Ammonoidea which have been described from this continent, was prepared by Professor Arthur K. Miller, of the University of Iowa. The cards for other groups of Devonian invertebrates are being prepared by American and Canadian specialists and will be issued as rapidly as they are completed.

These cards are not to be mere scissors and paste compilations of previously published facts and figures. They are to carry many new and better illustrations of type specimens and previously unpublished information. Aided by grants from the Geological Society of America and the Wagner Free Institute of Science, Professor Miller was able to visit the museums where the type specimens of North American Devonian ammonoids are preserved and study and photograph them. The cards bear eloquent testimony to the thoroughness of his work and the care with which he prepared them.

This portion of the catalog will prove an invaluable tool for students of Devonian fossils, not only in North America, but throughout the world. Accurate, up-to-date, beautifully printed and easy to use, it should both inspire those who use it to better work and help to make that better work possible. The conception of such a monumental undertaking proved that North American paleontologists have vision and enterprise: the quality of its first published unit proves that they have the skill and the determination to carry out their program successfully.

B. F. HOWELL

A BOOK OF WONDER PLANTS

Illustrations of North American Pitcherplants. By MARY VAUX WALCOTT. Published by the Smithsonian Institution, Washington, D. C., 193 Quarto. Price $25.00.

FROM the earliest times the pitcherplants, conspicuous, strange and beautiful among the wild flowers of America, have excited the wonder and admiration of those who knew them. With their water-holding leaves and their evident equipment for attracting, trapping, holding and killing insects, they have always stimulated human curiosity. To the older interest has now been added the knowledge that some, at least, of the species digest the insects they have caught and utilize the product for the plant's own nourishment. Mrs. Walcott now publishes fifteen full-page colored illustrations covering all the known North American species, each with a descriptive text, and to this have been added maps and text by Dr. Edgar T. Wherry, showing the geographic distribution of the species, and a description, by Dr. Frank Morton Jones, of the marvelous interrelationship between pitcherplants and insects, the insects that they catch and utilize for food, the insects that pollinate their flowers, and the insects that live and thrive in the same pitchers that kill and digest other insects. Mrs. Walcott has produced a book that not only is a work of art, from the beauty and fidelity of its illustrations, but is a fountain of scientific knowledge regarding these amazing plants, and she also has told how they may be grown in our greenhouses, so that we may watch them at their insect-catching operations.

FREDERICK V. COVILLE

SOCIETIES AND MEETINGS

THE SOUTHWESTERN DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE sixteenth annual meeting of the Southwestern Division of the American Association for the Advancement of Science was held from April 26 to April 30, at Flagstaff and the Grand Canyon, Arizona, in conjunction with the Third Annual Tree-Ring Conference, Southwestern Section of the Society of American Foresters, Ecological Society of America and the Southwestern Conservation League. Host institutions were the Arizona State Teachers College at Flagstaff, the Museum of Northern Arizona, the Lowell Observatory and the National Park Service at the Grand Canyon.

Attendance was unusually large, as was also the number of scientists giving papers. The local committee especially should be congratulated for their efficient handling of the meeting, which, in addition to the unexpectedly large number of registrants, came at the beginning of the tourist season for Flagstaff.

In addition to the usual section meetings for presentation of papers, features of the meeting were: The address by the retiring president, Dr. Harold S. Colton, on "The Rise and Fall of the Prehistoric Population of Northern Arizona," and the John Wesley Powell Lecture, by Dr. J. C. Merriam, on "The Wilderness as a Teacher, Preacher, and Companion—a Study of the Contribution Made by a Great National Park"; the opening of the new quarters of the Museum of Northern Arizona and the reception at the home of Dr. and Mrs. Colton; the inspection of the Lowell Observatory; excursions to nearby points of interest; and, lastly, the excursions conducted by Park officials on the last day at the Grand Canyon.

At the business meeting at the end of the sessions, resolutions of thanks were sent to host institutions and to the officials at the Grand Canyon. Officers for the coming year are as follows:

President: F. E. E. Germann, University of Colorado, Boulder.

Vice-President: E. D. Ball, University of Arizona, Tucson.

The present Secretary-Treasurer was continued for another year.

Executive Committee: O. C. Lester, University of Colorado, Boulder (1937); E. F. Carpenter, University of Arizona, Tucson (1938); S. A. Northrop, University of New Mexico, Albuquerque (1938); F. W. Sparks, Texas Technological College, Lubbock (1939); and D. S. Robbins, State College, New Mexico (1939).

Biological Science Section: Chairman, R. J. Gilmore, Colorado College, Colorado Springs; *vice-chairman,* Donald M. Crooks, University of Arizona, Tucson; *Secretary,* R. H. Canfield, Las Cruces, New Mexico.

Mathematics Section: Chairman, Paul K. Rees, State College, New Mexico; *vice-chairman,* C. A. Barnhart, University of New Mexico, Albuquerque; *Secretary,* W. M. Craig, Texas Technological College, Lubbock.

Social Sciences: Chairman, F. H. Douglas, Denver Art Museum, Denver; *Secretary,* W. S. Stallings, Laboratory of Anthropology, Santa Fe.

The meeting of the division for 1937 will be held in conjunction with the Pacific Division and the parent association at Denver. Meeting places for 1938 and 1939 will be at Alpine, Texas, and Tucson, Arizona, with final decision as to which place will be associated with which date to be made later.

VEON C. KIECH,
Secretary-Treasurer

THE MINNESOTA ACADEMY OF SCIENCE

THE Minnesota Academy of Science held its fourth annual meeting as the guests of Carleton and St. Olaf Colleges at Northfield, Minnesota, on April 18, 1936. At the general meetings approximately 400 persons

were in attendance. For the first time since the reorganization of the academy, sectional programs were held, at which eighteen papers were presented.

A public lecture was given in the evening in the Skinner Memorial Chapel by Dr. W. S. Cooper, University of Minnesota, whose subject was "Forests and Glaciers in Southeastern Alaska."

At the business meeting 150 new members were taken into the academy. Important actions included the authorization of a committee to formulate plans for the organization of a Junior Academy of Science. Officers for the coming year include the following: *President:* Rev. Wendel Luetmer, St. Johns University, Collegeville; *Vice-President:* O. T. Walter, Macalester College, St. Paul; *Secretary-Treasurer,* H. K. Wilson, University of Minnesota, St. Paul; *Councilors:* E. M. Freeman, University of Minnesota, St. Paul; E. T. Tufte, St. Olaf College, Northfield; G. W. Friedrich, St. Cloud Teachers College, St. Cloud; Louis H. Powell, St. Paul Institute, St. Paul.

H. K. WILSON,
Secretary

THE OHIO ACADEMY OF SCIENCE

THE Ohio Academy of Science held its forty-sixth annual meeting at the University of Toledo, Toledo, Ohio, on April 10 and 11, under the presidency of Dr. Walter H. Bucher, of the University of Cincinnati. One hundred and seventy-three members registered for the meeting. The program was rich and full and carried out with great enthusiasm, the section of zoology offering 31 papers, botany 16, geology 16, medical sciences 5, psychology 17, physics and astronomy 26, geography 14 and chemistry 7. In addition, the sections of the medical sciences and zoology in a joint session staged a remarkable symposium on "Virus Diseases," the various phases of the subject being discussed by eminent scientists, both within and without the state. Another unique feature was a joint education program, engaged in by the sections of physics and astronomy and chemistry and the Ohio Physics Club. The visiting scientists also had the privilege of inspecting the Owens-Illinois Glass Research Laboratory, a laboratory unique in that it is constructed entirely of glass blocks, is insulated with glass wool and has no windows.

President Bucher chose for his presidential address "The Concept of Natural Law in Geology," which was delivered before a large, appreciative assemblage at the annual dinner. The invitation address was given by Dr. Roberts Rugh, of Hunter College, on the topic, "Endocrine Factors in Sexual Reactions of Amphibia," illustrated by excellent slides and a marvelous movie film.

Forty-one new members were received into the academy at this meeting, and the following members were elected to fellowship: Clyde Stewart Adams, Antioch College; Richard Bradfield, Ohio State University; Donald Joyce Borror, Ohio State University; Karl G. A. Busch, Capital University; W. Storrs Cole, Ohio State University; Ralph Howard Davidson, Ohio State University; Willis Conrad Fernelius, Ohio State University; Miss Margaret Fulford, University of Cincinnati; Jesse R. Harrod, Ohio Northern University; Edwin Elmore Jacobs, Ashland College; Josef Nissley Knull, Ohio State University; William A. Manuel, Ohio Wesleyan University; John Alden Miller, Ohio State University; Nicholas Mogendorff, University of Toledo; Paul W. K. Rothemund, Antioch College.

The following officers were elected for the ensuing year: *President,* Dr. Charles A. Doan, Ohio State University; *Vice-presidents—Zoology,* Dr. A. W. Lindsey, Denison University; *Botany,* Dr. Claude O'Neal, Ohio Wesleyan University; *Geology,* Dr. Fred Foreman, Oberlin College; *Medical Sciences,* Dr. R. A. Knouff, Ohio State University; *Psychology,* Dr. Garry C. Myers, Western Reserve University; *Physics and Astronomy,* Dr. G. E. Owen, Antioch College; *Geography,* Dr. R. B. Frost, Oberlin College; *Chemistry,* Dr. A. P. Mathews, University of Cincinnati; *Secretary,* William H. Alexander, Columbus, Ohio; *Treasurer,* Dr. A. E. Waller, Ohio State University; *Members of the Executive Committee,* Drs. Walter H. Bucher and H. H. M. Bowman; *Trustee of Research Fund,* Dr. William Lloyd Evans, Ohio State University.

Preliminary steps were taken looking toward the suitable observance of the fiftieth anniversary of the academy four years hence.

WILLIAM H. ALEXANDER,
Secretary

REPORTS

REPORT OF THE PRESIDENT OF THE NATIONAL RESEARCH COUNCIL OF CANADA

INDUSTRIAL investigations undertaken in the National Research Laboratories at Ottawa generally come to the attention of the council by one of three methods, according to information contained in the eighteenth annual report of the National Research Council tabled recently in the House of Commons by the Hon. W. D. Euler, minister of trade and commerce,

who is chairman of the Privy Council Committee on Scientific and Industrial Research.

Some problems are an outgrowth from the work of the technical officers engaged in a branch of research already in progress in the laboratories. When the solution of such problems is likely to render a new industrial development possible, every effort is made to complete the study and to make the results available to those who are in a position to put them to practical use.

Other projects brought to the council for attention come from private individuals or commercial organizations who either do not have the necessary laboratory facilities of their own to carry out the work or wish to obtain the assistance and technical advice of the specialists on the council's staff. Expenses in the conduct of researches of this kind are usually borne wholly by the organization or individual presenting the problem, and if results of commercial value are obtained, the agency sponsoring the study has first claim on them. It is stated that the council's laboratories do not compete with recognized commercial laboratories in the field of routine analysis or testing; many requests for analyses are received, but the senders are always referred to established testing laboratories doing work of this kind. Tests of a kind that outside laboratories are not equipped to do are carried on in the council's laboratories when the necessary equipment is available. Approved schedules of rates govern the charges made for such services.

The third type of industrial problems comprises those presented by individuals or organizations who are not in a position to finance the project in full. Proposals of merit, that appear to have useful possibilities, particularly in the way of providing new or more profitable outlets for materials of Canadian origin, are sometimes undertaken as joint investigations with the industry concerned; the results of such studies become the joint property of the council and the participating agency.

Problems of broad general interest, such, for example, as the drying of tough and damp wheat, cold storage research, research under the associate committees of the council on field crop diseases, coal classification and analysis, electrical measuring instruments and grain research, are all reported promptly and the results are immediately made available to the interested industries and to the general public.

Two associate committees were reconstituted during the year under review, one to assist in work on problems of aeronautical research arising from the increased interest in civil aviation, and the other on the Trail Smelter smoke problem, because under the proposed terms of settlement between the governments of Canada and the United States evidence of damage done in the Northport area since 1931 would have to be considered.

Five joint associate committees of the Dominion Department of Agriculture and the National Research Council were set up with a view to the better coordination of research in the agricultural field. These joint committees deal respectively with problems of agriculture, field crop diseases, grain research, wool research and weed research, and their memberships are fully representative of all the interests concerned.

Reference is made in the president's report to the change in the form of the *Canadian Journal of Research,* which is now published in four sections—physical, chemical, botanical and zoological sciences. More than 600 papers by Canadian scientists, it is reported, have already been published, and it is noted that most of these papers contain the results of researches undertaken with the assistance of the National Research Council.

An important announcement in the report relates to the establishment of the Canadian Research Institute of Launderers and Cleaners, of which most of the power laundries in Canada are now members. The institute grew out of the laboratory service provided by the council to advise launderers regarding their methods and materials, and is directly financed by the industry itself.

In a general statement on world activities in research, attention is directed to the advances being made, particularly in Japan, Russia and Great Britain, in fostering national research programs as a means of promoting industrial and commercial expansion. It is noted, for example, that Japan maintains 45 research institutes employing 3,500 men, of whom more than 1,000 are scientific experts. Russia has 840 such institutes or more than twice as many as in 1930, and in these 47,900 men are at work. Expenditures on research in Russia are said to amount to approximately $500 millions annually, and it is planned by the end of 1937 to have a capital investment in research institutions of $2,000 millions.

Apart from work done in the army and navy departments, Great Britain spent $3,275,000 last year on research in building materials and construction, chemical investigations, the maintenance of the National Physical Laboratories and food research.

The total appropriation for research in the Canadian laboratories for the year under review is reported as $392,000.

Copies of the eighteenth annual report may be obtained without charge, by those interested, on application to the National Research Council at Ottawa.

SPECIAL ARTICLES

SYNTHESIS OF SUBSTANCES OF POSSIBLE PHYSIOLOGICAL ACTIVITY

THE methods developed by Fieser and Hershberg[1] for the synthesis of phenanthrene and hydrophenanthrene dicarboxylic anhydrides have been applied to the preparation (E. B. H.) of hydroxy and methoxy derivatives which are of interest for their possible oestrogenic activity. The condensation of succinic anhydride with 1-methoxynaphthalene afforded a suitable starting material for the synthesis of 9-methoxyphenanthrene-1, 2-dicarboxylic anhydride (m.p. 249–250°, corr.) by reduction, condensation of the ester with oxalic ester, cyclization and dehydrogenation. Plans to obtain the 7-substituted isomer by a similar process from the known γ-(6-methoxy-1-naphthyl)-butyric acid[2] were abandoned with the appearance of a paper by Cohen, Cook and Hewett[3] anticipating this part of our program. The 6-methoxy and the 6, 7-dimethoxy derivatives of octahydrophenanthrene-11, 12-dicarboxylic anhydride were prepared by the addition of butadiene to the unsaturated anhydrides obtained from anisol and from veratrol by condensation with succinic anhydride, reduction, ester condensation and cyclization. The ethers were demethylated after hydrogenation of the active ethylenic linkage. 6-methyl-7-hydroxyoctahydrophenanthrene-11, 12-dicarboxylic anhydride (m.p. 134.5–135.5°, corr.) was prepared similarly from γ-(3-methyl-4-methoxyphenyl)-butyric acid.[4]

As a further approach to the oestrone type of structure, the anhydride of phenanthrene-1, 2-dicarboxylic acid was converted into 1′, 3′-diketo-1, 2-cyclopentenophenanthrene (M. F. and E. B. H.) by condensation of the dimethyl ester with ethyl acetate. 1′, 3′-diketo-3, 4-cyclopentenophenanthrene (m.p. 201.4–202°, corr.) was obtained similarly.

We may report also the synthesis (M.F. and E.B.H.) of chrysene, 2, 3-dimethyl-6, 7-acechrysene (m.p. 222.6–223.1°, corr.), and 6, 7-dimethyl-3, 4-benzphenanthrene (m.p. 94.5–95°, corr.) from starting materials already described, by obvious extensions of the hydrocarbon synthesis developed by Fieser and Hershberg. The last two substances are being tested for carcinogenic activity. In connection with the latter problem 5, 10-dimethyl-1, 2-benzanthracene (m.p. 147–147.5°, corr.; picrate, m.p. 173.7–174.2°, corr.) has been synthesized for comparison with cholanthrene (M. S. N.). The method consisted in the reaction of *o*-tolylmagnesium bromide with naphthalene-1, 2-dicarboxylic anhydride to give a keto acid which yielded β-(*o*-toluyl)-naphthalene on decarboxylation, addition of the methyl Grignard reagent to the ketonic group of the keto ester, reduction of the resulting lactone by Martin's modification[4] of the Clemmensen method, cyclization to an anthrone and reduction with zinc and alkali.

By a reaction analogous to the reported Diels-Alder addition to cyclic unsaturated anhydrides, a new type of hydrophenanthrene derivative of interest in connection with the morphine problem has been made available (H. L. H.). Butadiene and 2, 3-dimethylbutadiene were successfully added to 3, 4-dihydro-1-naphthoic ester affording, after hydrolysis, 5, 8, 9, 10, 13, 14-hexahydrophenanthrene-13-carboxylic acid (morphine numbering), m.p. 137–137.5°, corr., and its 6, 7-dimethyl derivative, m.p. 162–162.5°, corr. These yielded phenanthrene and 2, 3-dimethylphenanthrene on dehydrogenation. The compounds are of significance because of the presence of a carbon-substituent in the position (C_{13}) assumed in the Gulland-Robinson formula for morphine to be occupied by the ethanamine chain. To provide a closer approach to the morphine structure a general synthesis of the required starting materials has been developed: α-keto-δ-phenylvaleric acid (m.p. 61–62°) is obtained by the acid hydrolysis of ethyl α-oxalyl-γ-phenylbutyrate and the ester is cyclized to 3, 4-dihydro-1-naphthoic acid. The 3-methoxy derivative of the hydrophenanthroic acid has been obtained and other syntheses are in progress.

The publication of the results of these and other experiments has been deferred for a time, pending the preparation for the press by one of us (L. F. F.) of the posthumous papers of the late Samuel C. Hooker.

L. F. FIESER
MARY FIESER
E. B. HERSHBERG
H. L. HOLMES
M. S. NEWMAN

HARVARD UNIVERSITY

[1] L. F. Fieser and E. B. Hershberg, *Jour. Am. Chem. Soc.*, 57: 1508, 1851, 2192 (1935).
[2] A. Butenandt and G. Schramm, *Ber.*, 68: 2083, 1935.
[3] A. Cohen, J. W. Cook and C. L. Hewett, *Jour. Chem. Soc.*, 52, 1936.
[4] E. L. Martin, *Jour. Am. Chem. Soc.*, in press.

POTASSIUM: A BASAL FACTOR IN THE SYNDROME OF CORTICOADRENAL INSUFFICIENCY

AN increasing number of regulatory functions is now being ascribed to the adrenal cortex. These might be controlled by a number of hormones elaborated by the gland, or possibly the manifold effects of adrenal insufficiency are due to the breakdown of a single regulatory mechanism, to which the other effects are secondary.

The morbid anatomy of animals dying of adrenal insufficiency does not give any definite indications as to the cause of death; more striking changes are found in the blood chemistry during the course of the syndrome. These are, briefly, lowered sodium and

glucose contents, low alkaline reserve, high non-protein nitrogen and high plasma potassium. Of these changes perhaps the least attention has been paid to the last named.

A rise in blood potassium in both experimental adrenal insufficiency[1,2,3,4] and in crises of Addison's disease[5] has, however, been reported in the literature. It has also been found that corticoadrenal extracts lower the high blood potassium of adrenal insufficiency.[4] The increases reported are open to objection for two reasons. In the human the potassium rise might be due to hemolysis of red cells with a release of their high potassium content. In experimental animals it has been found that repeated withdrawal of large amounts of blood will of itself raise blood potassium.[6] Since the cat has been shown to have identical values for cells and plasma the work here reported is not open to the first objection. A new method[7] for determining potassium in 0.2 cc of ear-blood eliminated the second.

The object of the research briefly reported in the present paper was to elucidate the following points:

(1) Is adrenal insufficiency necessarily associated with disturbances in potassium metabolism?

(2) Can the symptoms of adrenal insufficiency be reproduced in normal animals by raising the plasma potassium to the same extent by injection?

(3) What is the mechanism whereby the adrenal cortex regulates potassium metabolism?

The first question was answered by a series of analyses performed on 27 cats, from which it followed that the normal blood potassium level for cats is 19.9 (14.0–25.8) mg per cent. In adrenal insufficiency the average of 51 analyses was 29.9 (15.6–46.1) mg per cent. The values found in the second group varied widely for different animals or for the same animals on different occasions; they tended to rise with the development of the syndrome.

Somewhat greater difficulties were encountered in finding a means of maintaining high blood potassium in normal animals. Studies[8] of the effects of intravenous injections of small amounts of potassium salts showed that 60 mg of potassium (as 2 per cent. KCl) led to an increase of 50 per cent. in plasma K, which was back to normal within 6 minutes, whilst injection of larger amounts caused death. The method finally evolved in the present research was to give intraperitoneal injections of 10 per cent. KCl, in amounts of a quarter of the lethal dose, at appropriately spaced intervals. Cats so treated will exhibit progressively the gross symptoms of adrenal insufficiency when the blood potassium level remains higher than 30 mg per cent. for several hours. If the injections are made at more frequent intervals, plasma potassium will continue to rise, until death ensues shortly after a value of 60 mg per cent. has been attained.

In correlating the observed symptoms of adrenal insufficiency and of experimental potassium poisoning with the blood potassium level we found that anorexia seems to be present at about 30 mg per cent. If this level is maintained for some days asthenia also appears. In acute cases, however, the severe muscular asthenia seems to be correlated with a level greater than 40 mg per cent., and terminal convulsions with blood values of 50 mg per cent. or more.

In the bilaterally adrenalectomized cat, death results within a few hours of a single injection of potassium chloride not exceeding one fifth of the ordinary lethal dose. During the period following injection, the animals will pass rapidly through the stages of corticoadrenal insufficiency to the terminal stage of complete prostration, which would otherwise have been reached many days later. The rise in blood potassium is much greater and more prolonged than that found in the normal animal. As in the normal cat, death takes place when the blood potassium rises to 60 mg per cent. The findings at autopsy conform to those ordinarily found in terminal corticoadrenal insufficiency. The same applies to normal cats in chronic or acute potassium poisoning; in addition, the microscopic anatomy of their adrenal cortex indicates that it has been concerned in the process.

The question remains as to whether the high blood potassium of adrenal insufficiency is a consequence of renal retention alone, whence cortin would be essential for normal potassium excretion, or whether the rise follows from augmented liberation of intracellular potassium due to cortin deficiency. The rise in potassium should be roughly parallel in tissues and blood if the former factor is alone involved. Actually the values found for skeletal muscle are slightly lower than normal, whence it is concluded that both of the above factors are concerned in the rise in blood potassium.

Other symptoms of the syndrome may be considered to be secondary to the rise of potassium. Thus, depletion of sodium may be ascribed to the diuresis due to high potassium.[9] Low blood sugar has been observed

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after injection of potassium.[10] Muscular weakness has long been known to be associated with high blood potassium, and since this applies also to cardiac and smooth muscle it accounts for the circulatory disturbances. Dehydration of the blood, often reported in adrenal insufficiency, may be considered a consequence of diuresis and stasis. Finally, the lesions found in the kidney in potassium poisoning are of the same type as those in adrenal insufficiency. The renal lesions, low filtration pressure and diminished circulatory volume would also account for the uremic symptoms of late adrenal insufficiency.

Considerable variations in the survival time may be the result of the application of other mechanisms which may be brought into play, such as selection or avoidance of food and muscular activity. The latter has been shown to lower muscle potassium[11] and increase muscle sodium, thus bringing about the reverse changes in the blood. An adrenal insufficient animal as a rule does not tend to move unless disturbed and any excessive activity thus produced shortens its survival period. This would agree with the observations that muscles from adrenalectomized animals fatigue readily and that normal animals can be protected against fatigue by injections of cortin. It has been found that patients with Addison's disease have a greatly increased capacity for doing work after cortin administration.[12] Preexisting lesions of the kidneys would also lead to a more rapid course of the syndrome. Where the survival time is long, the results of individual sensitivity of different organs will complicate the picture, and death may often result from secondary causes. For these reasons it is not claimed that the terminal stages of the syndrome are in every case identical with those of potassium poisoning, but it is felt that the latter is the basal cause.

Preliminary experiments performed on mice, rats and guinea pigs have afforded some evidence that cortin has a protective action against potassium. Work is now in progress on the application of this finding to the assay of cortin.

Feeding insufficient animals with high potassium diets was found to aggravate the condition in cats, and in rats during the first few days following adrenalectomy. Similar results with dogs have been reported recently.[13]

In the therapy of Addison's disease it might be of greater importance to eliminate potassium from the diet than to administer high doses of sodium chloride, and probably the best results could be expected if both of these measures were used. Finally, cortin administration would appear to be indicated in many other conditions involving a rise in blood potassium, such as nephritis, traumatic shock and certain acute febrile diseases.

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Conclusion

It is believed on the basis of the above findings that an important function of the adrenal cortex is the regulation of potassium metabolism and that the various known symptoms of corticoadrenal insufficiency may be explained in terms of a disturbance of cortico-adrenal-potassium interrelations. It is further considered that the beneficial action of cortin in certain other pathologic conditions would suggest that the same mechanism is involved.

R. L. Zwemer
Richard Truszkowski
College of Physicians and Surgeons
Columbia University

DIETARY PRODUCTION AND PREVENTION OF ANEMIA IN LARVAL AMBLYSTOMA

Amblystoma larvae growing rapidly on a diet of raw beef liver developed long and pointed gill filaments with an abundance of red blood cells flowing through the capillary network. In contrast, larvae fed on raw beef muscle ate less, grew more slowly and had shorter gill filaments with a relatively smaller quantity of blood. This growth rate was raised when the beef muscle was powdered and formed 60 per cent. of a synthetic ration containing carbohydrate, fat, cod-liver oil and yeast; there was also an abundance of blood with deeply colored red cells and its rapid flow through the marginal vessels rounded the ends of the gill filaments. On a diet with the same protein: carbohydrate: fat ratio and the same vitamin supplement, but deriving the protein from a highly purified casein and from powdered milk, larvae grew poorly and had short curling gills with pointed filaments. By use of a low-powered microscope it was seen that the gill circulation of these larvae carried few and pale erythrocytes as compared with that of larvae fed on the synthetic beef muscle diet, and these observations were confirmed by standard blood tests (red cell counts and Newcomer readings of hemoglobin). It was possible to alter the severity of the disease and to vary the length of time before death by quantitative regulation of the diet, but development was rarely carried through the first visible changes preliminary to metamorphosis.

Supplementation of the anemia-producing diet with iron and copper, separately and combined at three different levels, had no effect upon the retarded growth nor upon the anemia. The disease was less severe

when crude casein was used in the ration, and a still higher degree of prevention was attained when the purified casein mixture was supplemented with 5 per cent. of powdered yeast. When an equivalent quantity of liver extract was used as a supplement, however, the increase in number and color of red cells was greater, growth was accelerated more, and development was made through successful metamorphosis; this treatment was also found to have a curative effect. Yet, 5 per cent. or 10 per cent. of liver extract added to the casein-milk powder diet did not produce so high a level of growth and erythrocytes as resulted from use of the raw beef liver or the synthetic beef muscle diet; furthermore, metamorphosis was not attained so early.

The rate of growth, red cell formation and development toward metamorphosis was proportional to the amount of a particular liver extract included in the diet, but quantitative relations were not exact between different extracts known to be of the same clinical potency. This led to the question whether the beneficial effect of liver extracts upon these larvae was due to the pernicious anemia factor or to some other constituent. As supplementation with liver extracts did not entirely compensate for the inadequacy of the diet with purified casein, it seemed probable that the deficiency might be due to poor protein constitution or digestion. Accordingly, some of the amino acids which were low in this diet were increased to the levels contained in the synthetic beef muscle mixture. Cystine alone or with alanine produced no significant effect upon growth or erythrocyte level; nor did their combination with glycine, although the three together caused an improvement of general condition. When arginine was added to the casein-milk powder diet with cystine, there resulted a striking and prolonged increase in erythrocytes, hemoglobin and growth; the improvement produced by the arginine was not permanent, however, unless liver extract also was used as supplement.

ESTHER M. PATCH
THE UNIVERSITY OF WISCONSIN

SCIENTIFIC APPARATUS AND LABORATORY METHODS

DIFFERENTIAL STAINING OF THICK SECTIONS OF TISSUES

WHILE studying human scalps for racial differences it was found that thin sections did not give a clear idea of the relationships of the hair follicle to its appendages and adjacent tissues. As many reconstructions were impracticable, thick free-hand sections were made, after the manner of the early histologists, and cleared in iso-safrol. Later, thick sections from tissues embedded in nitrocellulose were cut and a technique for differential staining developed.

Sections prepared as outlined below lend themselves well to low- and high-power study. The stereoscopic effect obtained with a binocular dissecting microscope is especially adapted to study of the topography of tissues, and with a strong light source the finer details can be studied with high dry and oil immersion objectives. The transparency of the stain depends upon slow, dilute staining and long differentiation as well as upon thorough dehydration before clearing. This technique has been tested on different tissues; the less dense tissues afford good results up to 400 micra. In general, the density of the tissue must be a guide to the thickness. The time given below for the steps in the procedures will vary slightly according to the type of tissue, kind of fixation and the thickness. The time of differentiation, as in the case of thin sections, is determined according to the particular structures to be shown.

Sections 100 to 400 micra were cut by microtome from tissues embedded in low viscosity nitrocellulose. One hundred micra sections may be cut serially in 95 per cent. alcohol and fixed to slides with Mayer's egg albumin by Rubaschkin's clove oil method, but thicker sections must be handled separately. Best results are obtained when the nitrocellulose is removed before staining, although the procedures given below for hematoxylin-eosin and iron hematoxylin may be used when the nitrocellulose is retained to support the tissues.

Tissues should be turned frequently to allow penetration of the reagents from all sides.

I. *Removal of nitrocellulose and preliminary to staining:*

(1) Absolute alcohol—1 hour.
(2) Equal parts ether and absolute alcohol—24 to 36 hours; change solution once.
(3) 75 per cent. alcohol—30 minutes.
(4) Distilled water—30 minutes.
For tissues fixed in Zenker's solution:
(5) Lugol's solution—12 to 24 hours.
(6) Hypo solution, 5 per cent.—until white—1 to 2 hours.
(7) Distilled water—8 to 12 hours.

II. *Hematoxylin-eosin:*

(1) Delafield's hematoxylin, 5 to 8 drops in 50 cc distilled water—8 to 12 hours.
(2) Tap water or distilled water containing a few drops of lithium carbonate until nuclei are blue—5 hours.
(3) Eosin solution, pale pink in distilled water—until sections are pale pink.

(4) Absolute alcohol, 2 changes—3 to 5 hours.
(5) Xylol until clear—1 to 2 hours.
(6) Mount in damar, placing small drop of damar on slide beneath sections as well as to cover them.

III. *Hematoxylin-eosin-azure II:*
(Eosin-azure II may be used alone when it is not necessary to stain nuclei well).
(1) Delafield's hematoxylin as for hematoxylin-eosin.
(2) Tap water—3 hours.
(3) Distilled water—30 minutes.
(4) Eosin, 3 cc 0.1 per cent. aqueous solution, add 50 cc distilled water and 5 cc 0.1 per cent. solution azure II—5 to 12 hours.
(5) Differentiate in absolute alcohol 4 to 12 hours or until desired contrast is obtained between epithelial and connective tissues.
(6) Fresh absolute alcohol—10 minutes. Clear and mount as in II.

IV. *Iron hematoxylin:*
(1) Iron alum solution 2.5 per cent.—3 hours.
(2) Tap water several changes—3 hours.
(3) Regaud's iron hematoxylin diluted to pale amber color—until sections are black.
(4) 95 per cent. alcohol—30 minutes.
(5) Differentiate in saturated solution picric acid in 95 per cent. alcohol until only nuclei remain black.
(6) Tap water frequent changes until all picric acid is removed—8 to 12 hours.
(7) Absolute alcohol 2 changes—5 hours. Clear and mount as in II.

V. *Sections containing nitrocellulose:*
Stain as in II or IV. Following staining:
(1) 75 per cent. alcohol—1 hour.
(2) 95 per cent. alcohol—3 to 5 hours.
(3) Creosote solution (1 part creosote, 1 part toluene, 2 parts xylene) until completely clear. Mount as in II.

MADELINE KNEBERG

DEPT. OF ANTHROPOLOGY
UNIVERSITY OF CHICAGO

A CONVENIENT RESISTANCE FOR DETERMINATION OF REDOX POTENTIALS IN BIOLOGICAL FLUIDS

A DISCOURAGING source of error in the measurement of redox potentials in many biological fluids is the rapid polarization of the cell. The obvious remedy, high resistance in the galvanometer circuit, has been adopted in most laboratories. Many of these devices are inconvenient to manipulate or to assemble. The writer has found that a series of radio grid leaks (or resistors) connected to a multiple point switch allowed a rapid adjustment of the potentiometer with a minimum flow of current from the cell. The device, Fig. 1, was made for $4.00.

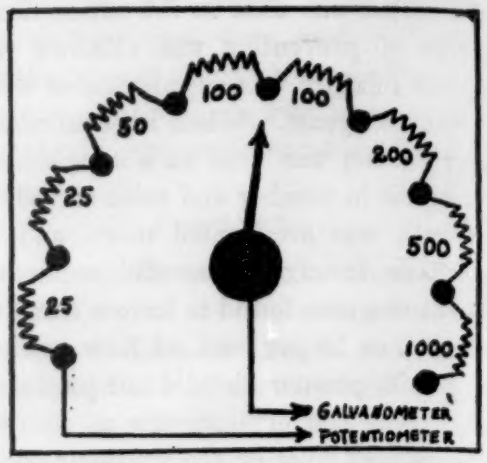

FIG. 1. Variable resistance for measurement of redox potentials of biological fluids. Unit resistance values above are in terms of 10^3 ohms.

The variable resistance is placed in series in the galvanometer circuit. About 500,000 ohms are switched into the circuit. This resistance is cut down step by step until a galvanometer deflection can just be detected. The potentiometer is balanced and the process repeated step by step until the system is balanced with all the resistance cut out. Thus the minimum current necessary to deflect a galvanometer (sens. .018 microamperes) is drawn from the cell and polarization minimized. The values of the unit resistors need not be accurately known, since they are not concerned in the final measurement.

MONROE E. FREEMAN

COLLEGE OF AGRICULTURE
ORONO, MAINE

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